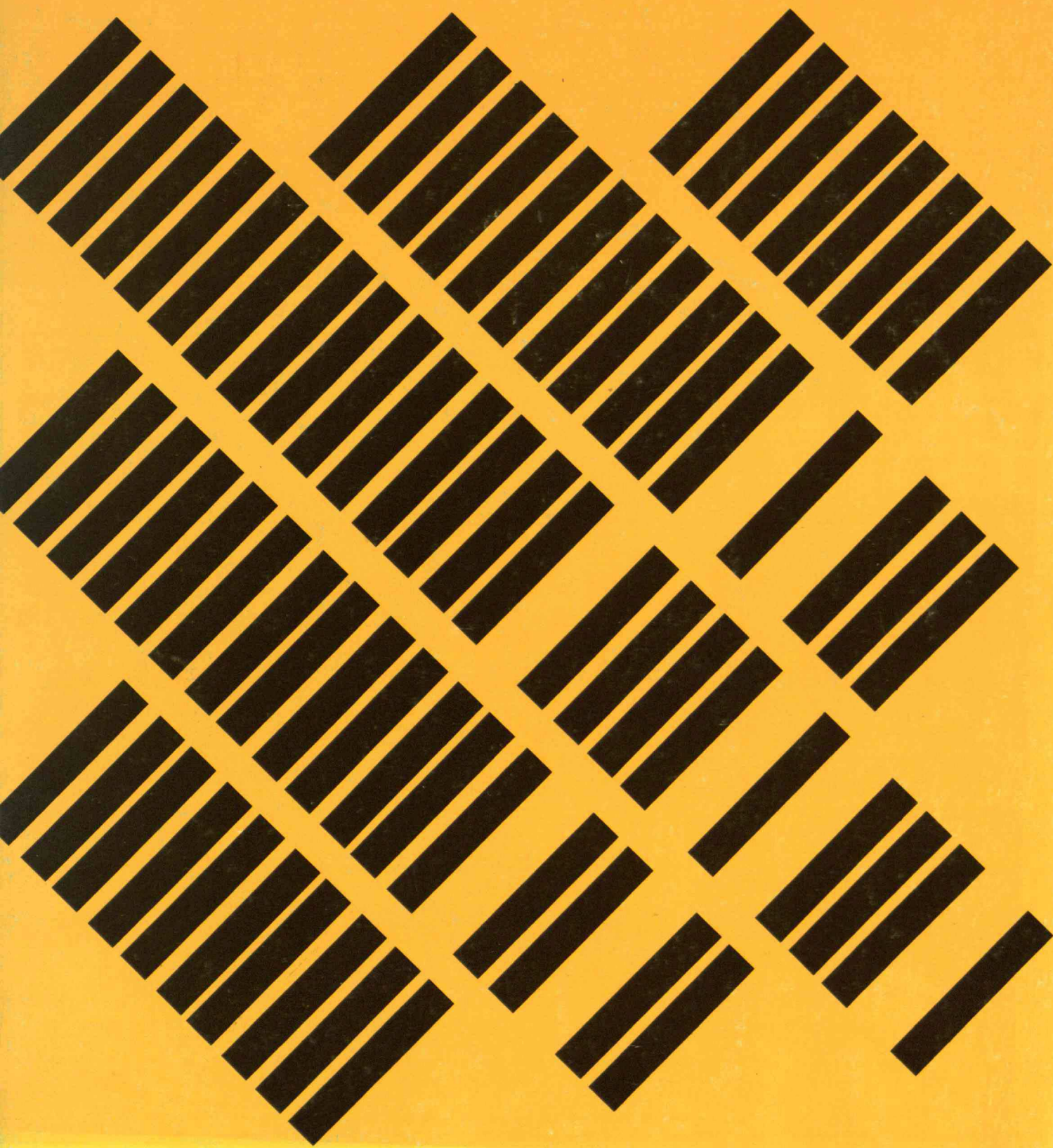


July/August, 1976 Price \$2.00

Technology and  
the Railroads

# Technology Review

Edited at the Massachusetts Institute of Technology



# technology review

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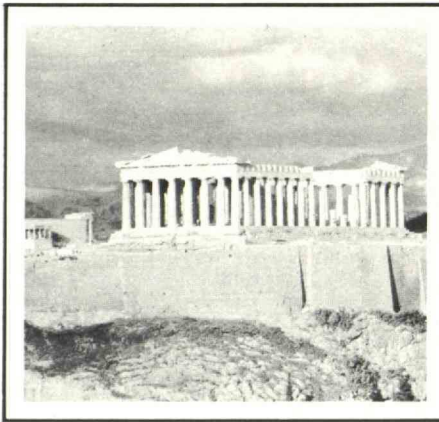
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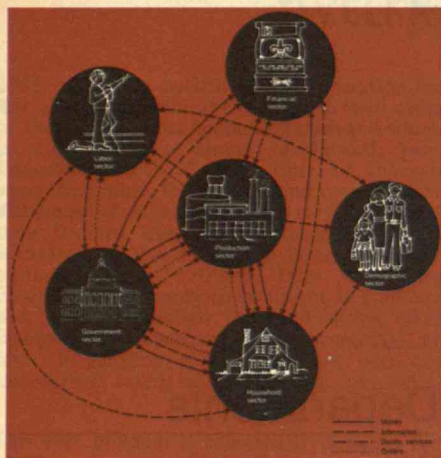
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## The Validity of System Dynamics: An Interchange

In the December issue of *Technology Review* is a report written by Dennis Meredith, the *Review*'s Managing Editor, on a model of this country's socioeconomic system being developed by Jay Forrester, Germeshausen Professor of Management at M.I.T., and his System Dynamics Group ("The National Model," pp. 14-16). When more details of the model are released, it is likely to become the center of major controversy as did its predecessors, the Urban Dynamics and the World Dynamics/Limits to Growth models. It is therefore appropriate to review system dynamics models briefly to shed light on some of the major causes of controversy.

A system dynamics model consists of a set of relationships which its creators consider important to explain the behavior of the system under study. In developing these relationships, the modelers are relatively unconstrained in the variables or equation forms which they may use. The variables need not have uniquely observable real-world values and the equations need not be estimable by econometric techniques. This is both the strength and weakness of system dynamics.

The relatively free equation structure makes it possible to model important real-world relationships which cannot be adequately represented in an econometric model. At the same time, the modeler is required to offer little proof that a relationship that he believes to exist in the real world actually does exist, or is of the strength the model assumes. Accordingly, it is not surprising that careful inspection of a system dynamics model frequently uncovers major relationships that appear to be questionable or highly exaggerated.

Particularly troublesome is the frequency with which major conclusions of

these models have depended upon such relationships. Professor Forrester's Urban Dynamics model, for example, contains the *assumption* that increasing a city's skilled labor force by 100 persons results in a reduction of about 50 in the total number of jobs in the city, both filled and unfilled. With such an assumption, it is scarcely surprising to find that the model indicates that a program which is designed to increase a city's skilled labor force by training the unskilled will result in an increase in unemployment.

It is possible, of course, to test the sensitivity of a model's behavior to changes in any assumption or set of assumptions; and the System Dynamics Group does indeed promise to conduct such tests. Their record for reporting such tests, however, leaves much to be desired. Most of the interesting policy conclusions drawn from the Urban Dynamics model are highly sensitive to certain critical relationships. Yet in only one instance does *Urban Dynamics* (M.I.T. Press, 1969) discuss the sensitivity of a policy test to a behavioral assumption.

The *Technology Review* report states that the new National Model will be "validated" by determining how well it describes the actual behavior of our economy for the last 125 years. Unless the model is being constructed without the use of any data on the nation's economy over this time period, such a test cannot accurately be described as "validation," which requires testing against an independent set of data.

Nonetheless, successful *calibration* of the model to replicate the behavior of the nation's economy would be an important test. But replication, by itself, should not be taken as in any way validating the policy analyses produced by the model. Indeed, it is entirely possible that the key relationships that determine the outcome of a particular policy test will enter minimally, if at all, into the attempted replication of our economic history.

A true evaluation of the merits of policy inferences drawn from the model's behavior will therefore require a careful review of the assumed relationships, embedded in the model, which produce the behavior. These relationships will be presented primarily as algebraic equations, although some accompanying textual description may be provided.

The algebraic presentation has the virtue of complete precision. But algebra is a language which many find forbidding. The number of persons who will have both the background and the interest to examine the model's assumed relationships will be limited. Yet every serious reader must examine them in order to verify that the model's behavior is indeed based on acceptable assumptions.

Two statements made near the end of the *Technology Review* report are especially disturbing in that they seem to reveal a naïve faith on the part of the System

Dynamics Group in the infallibility of the assumptions on which its model is based — a faith which reviewers of its past efforts would find totally unjustified.

In one statement, the Group argues that use of the National Model will result in the division of policies into three categories: those which are clearly desirable; those which are clearly undesirable; and a relatively small number of policies requiring further investigation. For two reasons, the contention that the last category will be "relatively small" appears unfounded:

— Most national policies produce not one effect but many, some desirable and some undesirable. The relative weights placed on the different effects represent value judgments and will vary from individual to individual. Even if the outcomes of all proposed policies were understood perfectly, the number of policies whose overall desirability could not be agreed upon would still be large.

— Agreement on a policy's desirability can exist only if there is agreement on the assumptions from which the model derives the policy's effects. Such agreement may exist within the System Dynamics Group. But perception of the key relationships of our socioeconomic system is not so uniform among the rest of us.

It is, in fact, by providing us with a clearer understanding of the differences in these perceptions, as well as their policy implications, that the model, with its algebraic precision, could perhaps have greatest value.

Also disturbing is the expectation that "instead of spewing out raw data to be coped with by planners, such [system dynamics] models offer rational, manageable frameworks that 'protect' planners from information overload." In other words, the conclusions of the models are presented in a much more accessible form than the assumptions on which they are based. Unless there is widespread agreement on the validity of these assumptions, such a presentation is little more than sophistry.

To the extent that system dynamics models raise questions about the complex ways in which our socioeconomic processes work, the models further the cause of rational inquiry. To the extent that an unsophisticated audience is led to accept the resulting policy conclusions because they come from computer models developed by a team of M.I.T. researchers, the models are reduced to novel vehicles for the presentation of unsubstantiated evidence.

Herbert Weinblatt  
Pittsburgh, Penn.

*Dr. Weinblatt is a Senior Analyst at CONSAD Research Corp. — Ed.*

### Dr. Forrester responds:

Mr. Weinblatt differs with the policy conclusions in *Urban Dynamics* but does not

invalidate the logic from which they arise. He is correct that earlier system dynamics publications have generated controversy. Responses have tended to be polarized with both strong support and strong disagreement. Negative responses have usually come from those who hope for quick short-term solutions to our deep and difficult social problems. Objections often fall into two categories — opposition to the conclusions without regard to the basis on which they were reached, and misinterpretations of the books. Mr. Weinblatt's objections seem to rest on the latter.

He states that *Urban Dynamics* "contains the assumption that increasing a city's labor force . . . results in a reduction . . . in the total number of jobs." In the *Urban Dynamics* model, managerial jobs depend only on the number of industrial units operating in the city — certainly a reasonable assumption. Skilled-labor jobs depend on the number of industrial units and on the rate of construction of new buildings — both being indicators of work done in the city. Underemployed jobs are assumed proportional to skilled-labor jobs (therefore proportional to the pace of economic activity), but modified by the degree of unemployment of skilled labor. It is this last relationship that Mr. Weinblatt misinterprets. The model assumes a moveable boundary between skilled jobs and unskilled jobs. When a surplus of skilled labor exists, skilled labor will be offered and will accept some jobs that would otherwise be filled by the underemployed group. During a shortage of skilled labor, the less skilled find more job openings and are pulled into better jobs than would ordinarily be available. If, as Dr. Weinblatt hypothesizes, the only change in the model variables were an increase in skilled labor, skilled labor would take some of the jobs available to the underemployed and reduce the number of underemployed jobs. The low-skill jobs held by skilled workers are not needed as a variable in the model and so are not computed. They exist implicitly in Equation 136 but are not included in the particular variables Dr. Weinblatt chose to consider. The effect of excess skilled labor is to cause skilled labor to fill some jobs otherwise available to the unskilled, thus diminishing the well-being of the unskilled. But such unskilled jobs filled by the skilled are not, in the model, considered satisfying to the skilled because of their more menial and lower-paying nature. The model structure appears to be a reasonable simplification of real life. A model must always have simplifications of this sort unless it is to be as complicated and unmanageable as an actual social system.

Mr. Weinblatt moves from this misunderstanding to a further misunderstanding of the effect of a job-training program. In Figure 4-3 of the book, the number of jobs in every category is seen to rise as a result

of the job-training program. In the model, jobs increase because the larger pool of skilled labor attracts industry to the city. But even more people are drawn to the city than can find jobs, so the job-training program does not reduce unemployment — a situation that seems consistent with the sparse information available about the aftermath of actual job-training programs in the cities.

Mr. Weinblatt asserts, without any specifics, that policy conclusions are highly sensitive to critical relationships, and he objects that "in only one instance does the book discuss the sensitivity of a policy test." In fact, there are two such tests, one in Figure B-9 and the other in Figure B-13. The first is presented as typical of the wide class of parameters whose values do not affect the policy conclusions. Regarding the second, the book states, "usually there are very few parameters that can affect policy recommendations. The one in this example is the only one that is known to exist in this model of urban dynamics." Now, as at the time of writing, the examples are thought to be fully inclusive, containing an example of the nearly general lack of sensitivity, and the one known assumption to which policy might be sensitive. Regarding the parameter that might affect policy, values quite unrealistic for a city in the United States would have to be chosen before conclusions would be altered.

There have also been assertions by other authors that policy conclusions in *Urban Dynamics* are sensitive to model assumptions, but, so far as I know, they likewise rest on erroneous analysis. The reader will find extensive discussions of these issues in two newer books — *Readings in Urban Dynamics: Volume I* (1974), edited by Nathaniel Mass, and *Readings in Urban Dynamics: Volume II* (1975), edited by Walter Schroeder, et al., both published by Wright-Allen Press, Cambridge, Mass.

It is true that few people are comfortable with precise algebraic notation. But there is good reason to hope that their number is growing. System dynamics, as a unifying theory to combine disparate disciplines of knowledge, is becoming a part of education in both undergraduate programs and in high schools. Successful experiments have carried the concepts of feedback loop structure in social systems down as far as the fifth grade. The most penetrating letters about *Urban Dynamics* that I receive come on lined notebook paper signed by high-school students. The letters show that the writers have read the book carefully, have interpreted it correctly, and know they are asking questions that go beyond the text. Often the student is seeking additional material to answer a debate with a teacher who has read the book superficially.

A system dynamics model is a theory of structure and behavior in a social system in exactly the same sense that Einstein's

law is a theory about the physical world. Such theories can never be proved. They rest on the absence of an experimental disproof. The formulator of such a law offers it when he believes it is likely to stand up better than laws already in use. Test, evaluation, and improvement continue indefinitely. At any point, a person uses the law that seems to him most persuasive. *Urban Dynamics* has achieved its impact because it strikes many people (though not yet a political majority) as more persuasive than the mental-image models that have been used in legislative bodies for deciding urban policy.

The *Urban Dynamics* model shows how many popular governmental policies of the 1960s should be expected to cause deterioration of the central cities. New York is an extreme case of a city that has vigorously followed an ensemble of policies that the *Urban Dynamics* model identifies as likely to cause a city to collapse. One would have hoped that such real-life validation might instead have been done using policies for urban recovery rather than policies that were already predicted to cause degradation.

Detrimental urban policies are characterized by actions that generate an excess of low-grade housing, attract low-income and unskilled people into a location where there are inadequate job opportunities, and drive out job-creating activities. Rent control, low-cost housing programs, and high demand for welfare seem humanitarian in the short run, but they create social traps which cut the unskilled off from the mainstream of economic activity. Such programs fill available land with old and declining housing, raise taxes, reduce industrial activity, and cause an imbalance of too many people compared to the available work. The programs attract the poor and dispel people with wealth, leadership, and labor skills, leading to an increased number of jobless. The programs create economic segregation. And given the historical conditions of the last few decades, the programs have worsened the racial segregation they were intended to help.

More alarming than the adoption of destructive policies by older cities is the way the same policies are being adopted by whole states in the old industrial regions of the U.S. Already, the result is becoming evident. We run the risk of a major segregation of the inner-city-versus-suburbs type in which the northeast quadrant of the country becomes the old decaying core. State policies in the Northeast are attracting the unskilled and trapping people in welfare, while the other three quadrants of the country become "suburbs," and attract wealth, jobs, management, and labor skills.

Such social processes are too complex and are perceived too slowly to become a part of informed political debate unless a coherent social theory, as in a system

*Continued on page 72*

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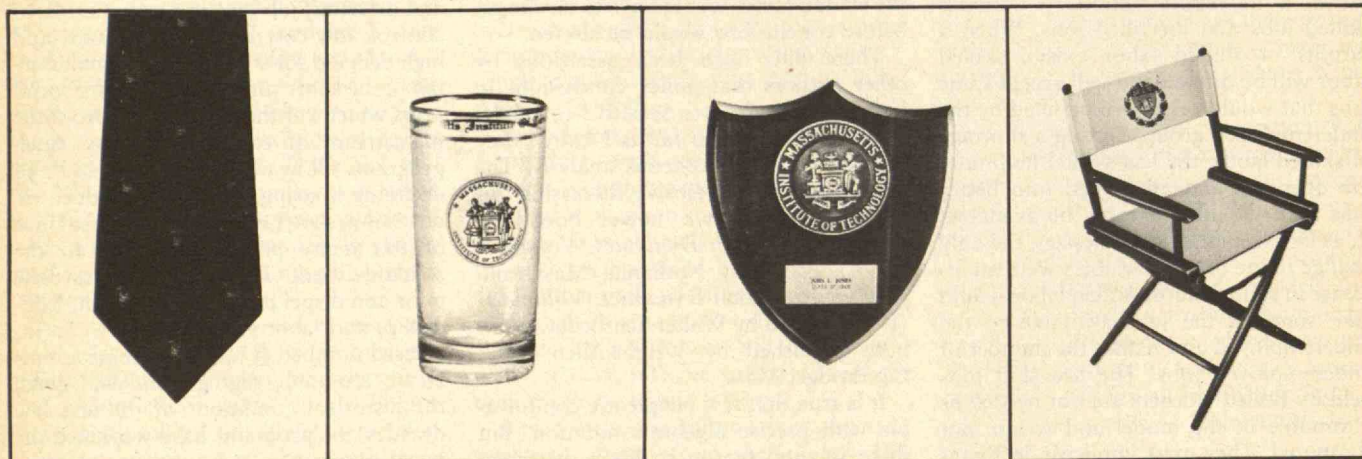
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# Economics for Good or Evil



Technology/Society  
by  
Kenneth E. Boulding

Eastern Kentucky University sponsored a conference on Adam Smith recently where the atmosphere recalled the joy of the Protestant Reformation as it rediscovered the Bible, free from the encrusted exegeses of successive generations. *The Wealth of Nations* is so full of good sense and humor, so humane, so aware both of the splendors and the pitfalls of humanity, that to go back to it is to experience a revelation. One almost sees Ricardo as a sort of dry Anastasius, and Marx a grim St. Augustine, damming the pure water of economic gospel into the great, stagnant lake of the church, that unholy city of central planning. And one yearns for a Tynedale, a Luther, or a Wesley to break the dam and let the water flow, even if it caused a flood, as of course reformations always do.

An unresolved question nags my thoughts. Has economics made any difference? And if it has, of what sort? On the positive side, we can credit Adam Smith with some of the ideas which gave birth to the modern world, and especially to the United States: a slight prejudice against using the government to protect special interests; a recognition of the government's responsibility to provide public goods such as education; concern for separation of church and state, and freedom of religion; a distrust of empire, and even of corporations; and the sense that people minding their own business will inevitably be guided by an "invisible hand" to serve the general good, so that the government's tasks can be limited.

On the negative side, classical economics is responsible for the English poor law of 1834, which set up workhouses and made the lives of the poor and the old more miserable. Nineteenth century economists took little interest in lowering the birth rate or in ameliorating poverty. They resisted the factory acts pushed through by the evangelicals, and prevented government from fulfilling its mandate to intervene wherever the "invisible hand" failed.

## The Apotheosis of Keynes

Economics produced Karl Marx, who undoubtedly was in apostolic succession to

Smith and Ricardo, even if he was also the bastard intellectual grandson of Hegel. Did Marx do more harm than good? I am inclined to think so, even in the face of the achievement of Marxist societies, simply because the human costs of that achievement have been so high, and those costs the direct result of Marx's false theories.

With Keynes the case is a little brighter. A testament to Keynes' contribution is the remarkable contrast between the 1920s and 1930s, the pre-Keynesian era, and the 1950s and 1960s. The first half of this century saw the wretched, post-World War I era in Europe, the Great Depression, Hitler, and the Second World War. I give the 1920s and 1930s a straight F. In contrast, the 1950s and 1960s deserve at least a C-plus, and perhaps even a B. There was no great depression; so far there has been no third world war; we have gotten rid of the colonial empires; the rich countries have grown a lot richer and the poor countries have grown a little richer, though the really poor may have gotten poorer. We cannot solve the problem of inflation, and we nervously await the limits to growth, but at least times are better than when we began the century. Economics can take some credit for this. One might paint a splendid baroque allegory of the period from the Marshall Plan to the oil embargo as the Apotheosis of Keynes.

## One Hand Clapping

Still the world remains uneasy. The population explosion, the impending exhaustion of oil and gas, the ever-present threat of nuclear destruction, the failure of development to raise the condition of the very poor, the unnerving combination of growing equity and growing tyranny in the socialist countries — all make it hard to give more than one and a half cheers for economics.

I may suffer delusions of grandeur, but oddly enough I believe I know what's gone wrong. The source of our trouble is the concept of production as a process by which the three so-called "factors of production" — land, labor, and capital — enter as inputs to produce products as outputs. And I must lay this disastrous

mistake pretty squarely at the feet of my beloved Adam Smith.

Land, labor, and capital have some status as factors of distribution insofar as they represent packages that enter into the price system as commodities. But they are not factors of production; instead, we must look to know-how, energy, and materials. Production, I repeat almost as a litany, whether the production of a chicken from a fertilized egg or of a building, an automobile, or even an organization from a blueprint, begins with knowledge or know-how, which in turn directs the selection, transportation, and transformation of materials into a product.

Any science whose elements are wrong will end in a blind alley. Land, labor, and capital have much in common with the four elements of medieval times — earth, air, fire, and water. They are plausible categories of common experience, but they are not elements; instead, they represent complex combinations of true elements. Similarly, land, labor, and capital are all complex manifestations of know-how, energy, and materials. To identify them as bedrock factors of production leads only to confusion, and has probably prevented economics from evolving as a science. Moreover, it led directly to Marx's fatal mistake of identifying labor as the *only* factor of production. The human cost of his mistake is too large to be calculated.

*Kenneth E. Boulding is Professor of Economics and Director of the Institute of Behavioral Science at the University of Colorado. He writes regularly for Technology Review.*

# Science at the Edge of Power: No Great Expectations



Washington Report  
by  
Colin Norman

After much agitation from many prominent scientists and a good deal of negotiating in congressional committee rooms, Congress finally passed a bill early in May to restore a science adviser and a small science policy office to the White House. A week later, President Ford signed the bill into law with a few perfunctory remarks about the need for a healthy scientific enterprise, and with many elder statesmen of the scientific community looking on.

So scientists are apparently returned to the inner corridors of power after a three-year forced absence. Unfortunately, the realities of presidential science advice are such that simply re-creating the post of presidential science adviser doesn't necessarily guarantee scientists influence in political affairs.

## Presidential Prerogatives to Ignore

To begin with, the Office of Science and Technology Policy (O.S.T.P.) couldn't have been re-established at a worse time. With the White House battered down for

the elections, and Mr. Ford desperately trying to fight off an assault on his right flank by Ronald Reagan, the administration isn't going to exhaust itself setting up proper working arrangements for a relatively minor White House office. Moreover, since Ford must be considered a likely candidate for political extinction in the near future, O.S.T.P. may have to settle into an entirely new White House organization next year. So nothing spectacular should be expected from the office, at least until after the elections are out of the way.

But even then, the science adviser's influence will not be guaranteed. A brief look at what happened during the latter days of the Johnson administration and throughout the Nixon administration clearly illustrates that the President can simply ignore his science advisers. Congress could, however, have given O.S.T.P. certain statutory functions which would have rendered its advice more difficult to ignore. But after much backroom discussion, it chose not to.

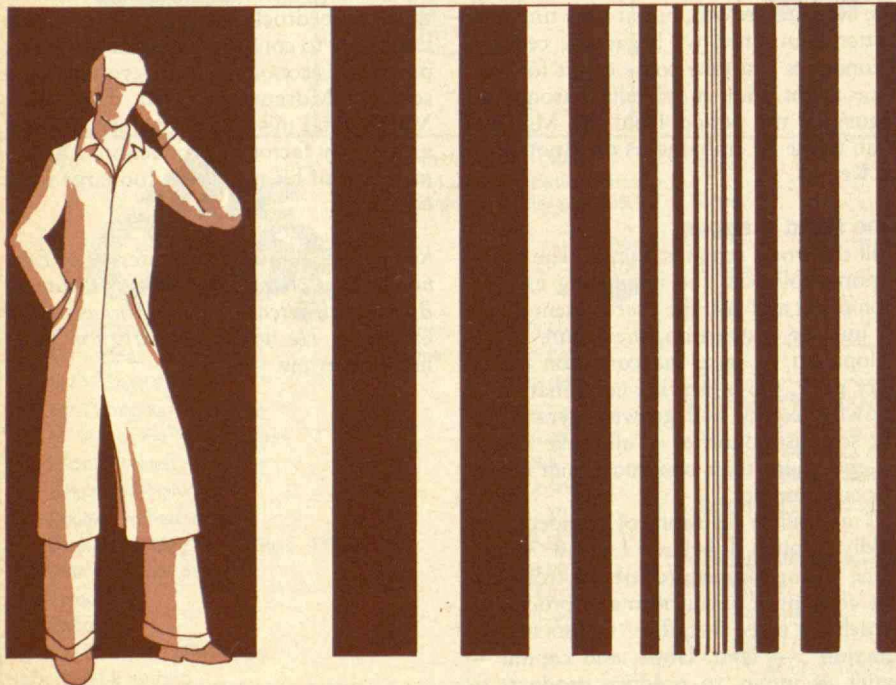
The problems of the former White House Office of Science and Technology (O.S.T.) began near the end of the Johnson administration and worsened during Nixon's tenure, largely because O.S.T. and the President's Science Advisory Committee (P.S.A.C.) — a top-level group chaired by the presidential science adviser — began to disagree with administration policy. Nixon was particularly annoyed by O.S.T.'s recommendations against building an antiballistic missile system and against continuing the SST program. His anger increased when the recommendations were made public during congressional hearings.

In the end, say insiders, O.S.T.'s influence was virtually nil; Nixon's science adviser, Edward E. David, Jr., scarcely ever saw the President, and in January, 1973, he resigned. Shortly thereafter, Nixon abolished O.S.T. and made the already overburdened Director of the National Science Foundation his adviser — and that modest concession thanks only to last minute intervention by senior Republican scientists, notably William O. Baker, President of Bell Labs.

The clamor from the scientific community, from a few members of Congress, and from Nelson Rockefeller for the reinstatement of a White House science policy apparatus finally persuaded President Ford to propose a bill. Of course, he might have reconstituted the Office immediately by executive order. But at least the fact that O.S.T.P. has been established by legislation makes an act of Congress, rather than presidential pique, necessary to dissolve it.

Given the diminishing influence of the first White House science office, many observers urged that the new advisory group be given a specific legislative charge. In particular, a significant statutory role in preparing the administration's budget request promised to enhance O.S.T.P.'s imprint on policy. But such legislation would infringe upon the President's traditional right to arrange his own office, and therein lies the chief reason why the bill took so long to transit the Congress.

Mr. Ford's bill would have established a modest operation of some 15 people



Drawing: Vaughn McGrath

headed by a single adviser. The bill passed by the House was a bit more ambitious, but at the same time would have allowed the President to define most of O.S.T.P.'s responsibilities. In contrast, the bill passed by the Senate, which was largely the work of Edward M. Kennedy (D.-Mass.), mandated the Office's functions in detail and gave the science adviser a powerful voice in the budget.

#### Contingent Authority

It took several rounds of congressional staff meetings to wear down the differences in the Senate- and House-passed versions of the bill, but when the result finally emerged, it was closer to the House version in several key respects. As far as budgetary authority is concerned, for example, the bill empowers O.S.T.P. simply to prepare a five-year outlook identifying problems and opportunities in science and technology, and to bring it to the attention of the Office of Management and Budget. O.S.T.P. will thus be little nuisance to the powerful budget office.

As for military matters, the bill requires only that the science adviser serve as a statutory adviser to the National Security Council. So although O.S.T.P. will have a chance to comment on military programs, it is not assured an eager audience in the White House.

O.S.T.P. will certainly be in a good position to coordinate and guide the government's science and technology enterprise — a task several government officials believe is not adequately performed by N.S.F. simply because that agency exists in the bureaucratic hinterlands. The bill specifies that the science adviser should be a member of the Domestic Council, and chairman of a new Federal Coordinating Council for Science, Engineering, and Technology, a committee comprising representatives from agencies that conduct substantial science and technology programs.

One other provision could become important. It establishes a President's Committee on Science and Technology to examine thoroughly the federal government's research and development enterprise. The committee, which will consist chiefly of distinguished non-governmental scientists and engineers, will make recommendations for organizational reform, and changes in program emphasis. When its study is completed at the end of two years, it could be kept in business if the President desires.

In the absence of a strong statutory base for its operations, O.S.T.P.'s influence will largely depend on the working relationship established between the President and his science adviser. If the President is willing to listen, O.S.T.P. could provide a valuable service.

*Colin Norman is Washington Correspondent for Nature and writes regularly for Technology Review.*

## MATERIALS RESEARCH CENTER REPORTS...

On Photoelectrolysis:  
A method for using sunlight  
to produce hydrogen.



Dr. A.J. Nozik and his group at the Materials Research Center have been exploring the liberation of hydrogen from water.

The liberation of hydrogen by photoelectrolysis of water is particularly interesting because hydrogen is valuable both as a chemical and as a fuel. Indications are that photoelectrolysis may represent an economically feasible alternative to present hydrogen production techniques which involve reacting methane or coal with steam.

Photoelectrolysis uses photoactive semiconducting electrodes arranged in an electrochemical cell. A successful process will require semiconducting electrode systems that respond efficiently to sunlight, that require no external electrical bias and that are both stable and inexpensive.

Very recently and for the first time the Nozik group has achieved photoelectrolysis of water into hydrogen and oxygen using simulated sunlight without the need for any external bias. To do this a cell was made with stable n- and p-type semiconducting electrodes illuminated simultaneously. Theoretical analysis of this n-p cell suggests that high conversion efficiencies using sunlight may be possible.

Photoelectrolysis has been achieved with polycrystalline (sputtered) semiconducting electrodes. The results compare favorably with those obtained from cells using single crystal electrodes. The latter are considerably more expensive.

Photoelectrolysis of  $H_2S$  into hydrogen and free sulfur has also been demonstrated. Investigations of other electrode systems and cell reactions are continuing.

Allied Chemical Corporation/Materials Research Center  
P.O. Box 1021R, Morristown, New Jersey 07960



# A Delicate Balance



**National Report**  
by  
**David F. Salisbury**

We were out sailing one night when my little sister first encountered diatoms.

"Look, the water's on fire," she squealed. The gentle waves and the boat's wake were etched in ghostly phosphorescence. It was an unforgettable sight provoking curiosity and a twinge of awe.

Diatoms — microscopic plants that wrap themselves in gemlike silicate houses — are more than curiosities, however. They are one of the ocean's most important food sources, and it now appears that pollutants in concentrations of only parts per billion affect them drastically.

Exactly what diatoms' extreme vulnerability portends for the rest of the ocean food chain is unclear. But the end result of pollution could be more jellyfish and emptier fishing nets.

Diatoms are members of the plankton, the marine community which drifts in the surface waters of the world's oceans. The plankton includes the eggs and larvae of fish and of such bottom-dwellers as oysters, mussels, and snails. But the bulk of the planktonic community consists of plant-like species — such as diatoms — called phytoplankton, and animal-like creatures, called zooplankton, which feed off phytoplankton and one another. The

plankton account for 98 per cent of the ocean's primary production. They form the bottom rung of the ocean food chain.

In Saanich Inlet on the eastern shore of Vancouver Island, B.C., scientists from several nations have been conducting experiments to help unravel the Gordian knot which binds marine life in order to predict the effect pollution has upon it. In huge polyethylene test tubes — each holding 2,350 tons of water — these scientists have been capturing natural ecosystems, adding pollutants in levels so low they are permissible in drinking water, and watching the effects. The experiments are known as CEPEX, the Controlled Ecosystem Pollution Experiment.

David W. Menzel, Director of the Skidaway Oceanographic Institute in Georgia and a CEPEX coordinator, summarized the results of the latest experiments. Copper, mercury, and several types of petroleum have been added in the parts per billion range. All appear to produce the same basic effect: first, the bacterial population explodes, then returns to normal levels within a few days. But at the same time, the large diatoms begin to disappear while the number of smaller diatoms increases. A drop in the activity of the zooplankton as they graze on these microscopic plants is also seen.

The pollutants were added in a single dose. Thereafter, their concentration declined steadily. But over the 30 days of the experiment, there was no evidence that the diatoms were reestablishing themselves.

Evidence from natural populations supports the universality of these effects. In highly polluted fresh water, nearly pure populations of the tiniest diatoms have been observed. After the oil tanker "Torrey Canyon" spilled 860,000 barrels of oil off the English coast in 1967, an unusually large number of microflagellates was found. And since the mid-1960s, the North Sea has manifested a decline in the number of diatoms. Nicholas S. Fisher of Woods Hole Oceanographic Institution suggested in the January issue of *Nature* that these observations may reflect the presence of persistent industrial pollutants.

T. R. Parsons of the Institute of Oceanography at the University of British Columbia, Canada, and W. Greve of the Biologische Anstalt Helgoland, West Germany, suggest that widespread dominance of small flagellates due to pollution could cause a jellyfish population explosion and jeopardize the world fish catch. They point to a fundamental split that they believe exists in the marine food chain that pollutants may be interrupting.

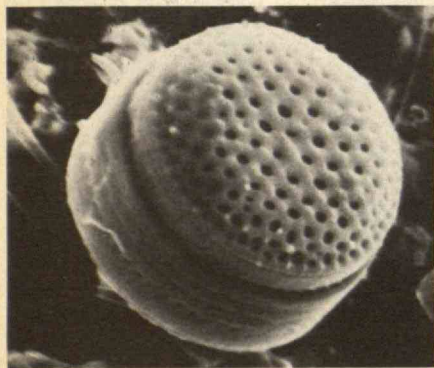
In one chain, small phytoplankton are eaten by small herbivores, which are in turn preyed upon by filter feeders — primarily jellyfish and sea gooseberries. Many fish do some filter feeding, but rely on spotting and catching larger prey, especially when they are young.

At the same time, another food chain links the larger diatoms, larger zooplankton, and young fish. Copepods are shrimplike fellows with oar-shaped feet. They grow to about the size of rice grains and are the major food source of smaller fish including sardines, anchovita, herring, and young salmon. They feed on diatoms and comprise over 80 per cent of all ocean animals.

In the Strait of Georgia, Andrew A. Benson of Scripps Oceanographic Institution has studied the ecology of this alternative food chain. It is a mysteriously orchestrated cycle. When spring comes to the Canadian Rockies, the snow melts and carries nutrient-rich waters into the strait. The diatom population explodes, and copepods, receiving some subtle signal, rise from the bottom where they have been hibernating and begin to feed. Simultaneously, young salmon arrive and feed on the larger copepods.

The CEPEX experiments show that young salmon do not grow when fed small copepods; yet, large copepods have difficulty feeding on smaller diatoms. Sea gooseberries and jellyfish grow rapidly on a diet of small copepods, says Dr. Parsons. So pollution should encourage jellyfish populations, and discourage populations of salmon.

Drs. Parson and Greve advance their argument as an hypothesis, not a theory, but their evidence is disturbing. It suggests  
*Continued on page 16*



Diatoms — microscopic plants within the plankton — are one of the ocean's most important food sources. And one of the most vulnerable. Growing marine pollution threatens to warp diatom populations so drastically that the fish catch may decline as a result. (Electron micrograph: Brookhaven National Laboratory)

# Have Any Bright Ideas?

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# Inhabiting Space: Planned U.S. and Soviet Stations



Special Report  
by  
James E. Oberg

The first decade of manned space flight taught the United States and the Soviet Union the principles of launching manned craft, controlling them in space for periods of a few weeks, and bringing them back to earth. Now these skills have been mastered, the next step in space exploration involves the establishment of long-duration manned laboratories where pilots and scientists can conduct research, taking advantage of the unique conditions of space flight. These prototype "space stations" will be put into orbit unmanned and visited by teams of astronauts or cosmonauts in smaller "space ferries," based on spacecraft already developed.

The advantages of semi-permanent expeditions over brief sorties are manifest. Heavy scientific equipment may be left in space to be used over and over again. Programs of observation can extend over many months instead of a few days at a time. Cumulative space effects on personnel and equipment can be studied.

Three space station projects — two American and one Soviet — have been developed so far. The United States Air Force "Manned Orbiting Laboratory" (MOL) project was formally initiated in 1965, and well into the design and test stage when it was cancelled in 1969, two years before launch. N.A.S.A.'s "Skylab," called "Apollo Applications" when it was conceived in 1966-1967, went through long development. A simpler version of Skylab was first planned; it was called the "wet workshop," since the actual working quarters were to be filled with liquid hydrogen at launch. In 1969 this gave way to the "dry workshop" concept, whereby Skylab would be launched fully outfitted, as a payload of a Saturn-V booster.

In the U.S.S.R., the "Salyut" (Russian for "Salute") space laboratory was conceived in the mid-1960s as the third generation of Soviet manned space vehicles, following the Vostok-Voskhod (1960-1966) and Soyuz-Zond (1966-present). The first Salyut was flown in 1971, but successful operations did not occur until 1974-75 with the flights of Salyut-3 and -4. In contrast with the one-shot Skylab, Salyut space stations will probably be launched at a rate of one or two per year

for the rest of the decade. And Soviet plans may eventually call for Salyut missions in semi-synchronous and even lunar orbit by 1980.

## Keeping up with the Jones's

Although press reports often represent the Skylab and Salyut space stations as twin projects, there are significant differences between the two vehicles. In terms of instrumentation, electrical power, size, flexibility, crew capability, and other important criteria, Skylab was by far the more powerful scientific research station. A Salyut module would fit easily *inside* the workshop portion of the Skylab. And Skylab established flight duration and mission achievement records not likely to be broken by the Soviets for several years.

On the other hand, Salyut missions are perhaps three to four times cheaper. They are part of a continuing, flexible program which will carry out a series of more ambitious flights during the second half of this decade, without competition from the extinct Skylab program.

A careful study of the mission capabilities and objectives of both nations' space station projects through 1975 reveals some interesting parallels. On criteria of size, weight, altitude, mission duration, instrumentation, crew composition, and primary experiments, the current Salyut is much closer to the cancelled MOL than to Skylab. Despite Moscow's claims to the contrary, their program seems to have been devoted as much to military as to purely scientific interests.

Thus one of the most puzzling aspects of the Salyut-1 (April-June, 1971) and Salyut-3 (July-August, 1973) missions is a mysterious "chimney" device in the largest section of the Salyut. Soviet specialists reported that it was a powerful telescope-camera to be used for studies of the sun and stars. Yet most official Soviet descriptions of the Salyut spacecraft ignored the instrument entirely, erasing it from photos of spacecraft models, or projecting a flap of spacecraft skin over the object. Western observers have nicknamed this latter phenomenon the "fig-leaf effect."

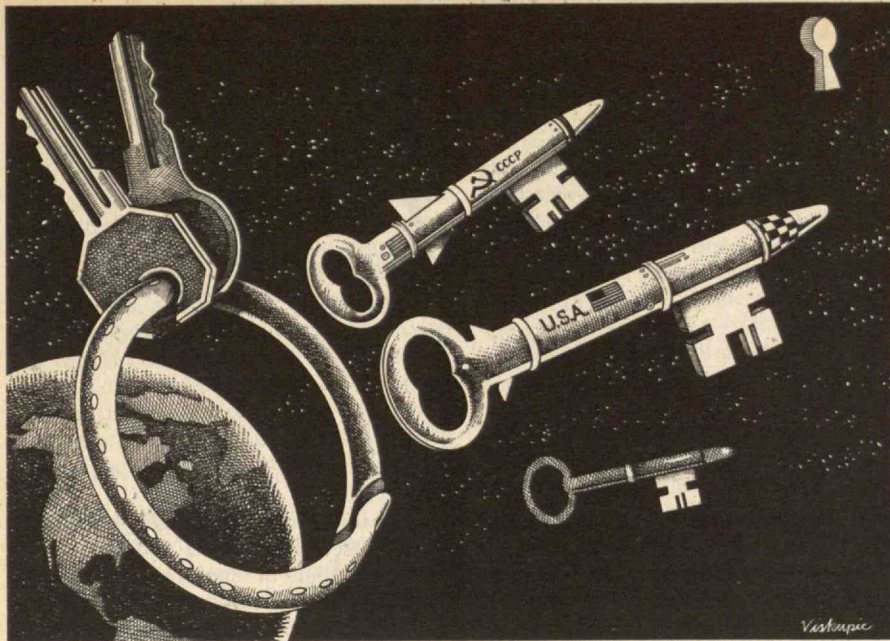
What were the Soviets trying to hide?

During the Salyut-4 mission in 1975, which was almost wholly devoted to scientific and engineering experiments, the cosmonauts described their version of the telescope-camera as the Orbiting Solar Telescope No. 1. The Soviet spacemen were forced to correct some serious engineering problems in the instrument — confirmation that this was its first flight in that particular configuration.

If the instrument were a powerful telescope-camera, what was it looking at during previous missions? Most western specialists conclude that the device is directly connected with ground photography, both to study earth resources (other cameras were on board for this general purpose) and to conduct military reconnaissance. While the U.S. has developed a long-duration, unmanned reconnaissance satellite called "Big Bird" (its effectiveness was one of the primary reasons for the cancellation of the manned MOL), the Soviets still must launch two dozen or more short-lived photographic satellites every year to survey military developments and deployments in other countries. So the Soviets are probably grooming a version of the Salyut space vehicle to replace that expensive program. At least the Salyut-3 mission during the summer of 1974 suggested as much, when two all-military crews were sent on 16-day visits aboard the station (the second crew never made it due to a rendezvous failure). At the end of 90 days, a "recoverable module" (presumably carrying film) was automatically detached from the Salyut and returned to earth.

## Fiction Becomes Science

The aims of the Salyut program are not entirely military, however, and the Soviets finally launched a true scientific space station on December 26, 1974. The Salyut-4 carried a respectable array of scientific instruments on board, designed to record astronomical, medical, and engineering observations. It flew at a record altitude (for the Soviets) — good for space observation but too high for the best ground photography. Despite a series of equipment problems and delays familiar to observers of long space missions, Salyut-4 is



regarded a complete success.

Future Salyut missions will continue the experiments — both military and scientific — begun in earlier flights. Boris Petrov, one of the U.S.S.R.'s top space scientists, has described stations assembled in orbit from Salyut-type modules launched separately. Such stations are expected to be in orbit by 1980. From a core module would protrude a number of "spokes" — docking ports for several Soyuz ferry ships. Eventually, a large space booster now under development will launch five Salyut modules simultaneously, to establish a space station manned continuously by rotating crews.

This same large booster (reported to have been launched unsuccessfully in 1969) could place a single Salyut laboratory module, much like those already tested, into semi-synchronous orbit ranging from about 400 to 24,000 miles in altitude. The period of this orbit is 12 hours, giving the station a long dwell time over the U.S.S.R. every day. Soviet "Molniya" communications satellites already follow this orbit — valuable for such specialized applications as weather observation, communications, and missile warning.

Salyut modules may be placed in lunar orbit to make manned or automatic surveys of the lunar surface and cislunar space. Such flights have been considered by Soviet space planners, although naturally no specific plans or dates have been announced. "Kosmograd," the long-awaited space laboratory-factory, will probably be ready for launch by 1980. This giant Skylab-type vehicle will have a crew of between 12 and 20 cosmonauts.

### Winging It

If the definition of "space station" demands that the vehicle be free-flying and of long duration the U.S. has no future space station scheduled. However, a flexible and powerful system — "Spacelab" —

is being built for use with the Space Shuttle rocket plane. The project is funded and directed by a European space agency in close coordination with N.A.S.A.

Current plans call for Spacelab flights of up to 30 days, with the laboratory module carried in the payload bay of the winged reusable launch vehicle. Two pilots and five scientists will make up the crew. At the end of the planned series of space experiments, the entire vehicle returns to earth for checkout, repair, and reuse. Half of N.A.S.A.'s Space Shuttle missions in the 1980s will carry Spacelab payloads.

The Spacelab will be modular with various combinations of pressurized sections and unpressurized pallet units for mounting equipment to be exposed to the space environment. A medical mission might call for an entirely pressurized version, while a mission devoted to space physics and astronomy might have one long pallet array with the crewmen living and working in shifts inside the pressurized forward cabin of the Space Shuttle.

A number of scientific missions for Spacelab are already in the instrument selection and design stage. Pallet-mounted instrument assemblies will by 1980-81 operate in solar physics, infrared astronomy, ultraviolet/visible astronomy, high energy astrophysics, space biology, and atmospheric and space physics. Other experiments in earth resources and related observational and experimental disciplines may fly on the same missions.

Space manufacturing will not be ignored either. Special supplementary power modules will be needed to support metallurgical processing, but engineers are also excited about the possibility of biological production — especially urgent vaccines and serums that might be produced ten times faster in weightless space.

Once the Space Shuttle/Spacelab system has been in operation for a few years, space scientists may decide some experi-

ments should be performed in space for periods longer than 30 days. And since the Space Shuttle cannot operate beyond that limit, new systems will be required.

A special module may have to be built to provide the same stabilization, temperature control, communications, and power that the Space Shuttle generates. This unit may be placed into orbit by a Space Shuttle and periodically resupplied with consumables. A Spacelab may be attached (and possibly exchanged on each resupply flight) to this prototype space station; crews of three to six astronauts could spend months in space. Depending on when — and whether — this option is funded, it could be operational in the mid-1980s or sooner.

N.A.S.A. has funded studies of full-fledged modular space stations possible by the late 1980s. A 12-man permanent space laboratory could be constructed from modules launched by Space Shuttle flights, as in the Soviet prototype. Special-purpose modules carrying instrumentation and equipment for unique experiments would be flown up. These could include modules for high energy astronomy, earth survey, power experiments, space biology, and space manufacturing. The space station would also control a series of free-flying modules devoted to astronomy and physics.

Every three months, the Space Shuttle would bring up a "resupply module" stocked with the consumables needed for station operation. An empty "resupply module" would be picked up at the space station for return to earth and recycling. Every six months, the entire 12-man crew would ride back to earth in a "crew transfer module" in the Shuttle's payload bay. Individual crew exchanges could also occur on the resupply visits.

This initial space station — which would need nine flights to set up and half a dozen flights a year to maintain (bringing supplies, crews, and new specialized science modules), could be in operation by the second half of the 1980s. It could be expanded as it was set up, in modular fashion, year by year.

Also under study are plans for a manned "power satellite" in synchronous orbit. This giant array of solar cells would beam electricity to earth on microwaves. The engineering, construction, and transportation problems are tremendous, but

*Continued on page 16*

N.A.S.A.'s Marshall Space Flight Center is conducting a survey of potential space station users and is soliciting inputs from the academic and industrial worlds. Potential users should request the report "Manned Orbital Facility: A User's Guide," from C. C. Priest, PS 04, N.A.S.A. — M.S.F.C., Huntsville, Ala. 35812.

# Innovation: Rising, Falling, or Changing?



**Special Report**  
by  
**John I. Mattill**

Has the U.S. lost its initiative in technological innovation and productivity? Or is our industrial society maturing to a new stage of development, in which innovation is a more subtle and perhaps less crucial process and productivity to be measured by broader new standards?

Opening an M.I.T.-sponsored conference on productivity in Washington this

spring, Jerome B. Wiesner, President of M.I.T., cited a series of recent difficulties which, though disparate and apparently unrelated, represent to him "ever-increasing deterrents to creative change" in the U.S. He spoke of increasing complications: shortages of capital and of investment incentives, "counterproductive" patent policies, growing government regu-

latory interventions, changing policies on basic research support, and the serious financial plight of "major research universities." This series of deterrents to the creation and use of new knowledge is "a social overhead which the nation cannot afford," said Dr. Wiesner. (A summary of his address appears on pages 54-60.)

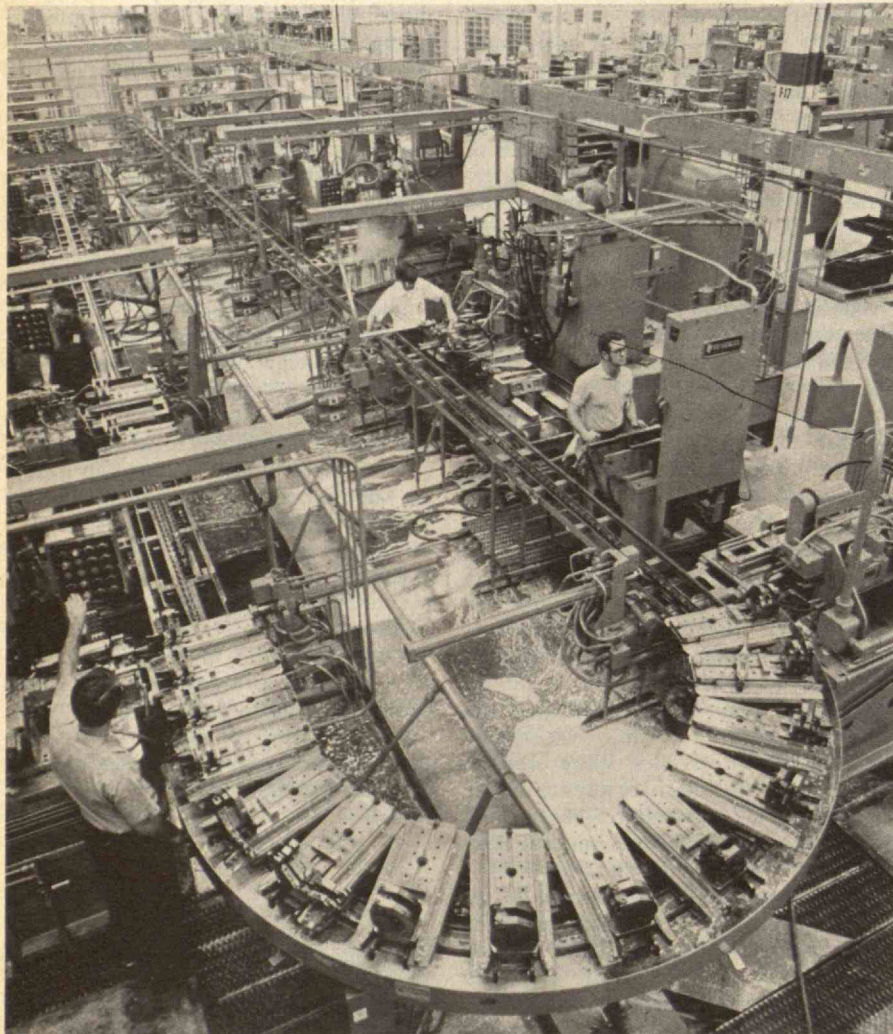
## How Not to Rock the Boat

The economists and historians who shared the platform with Dr. Wiesner tend to a more sanguine view: the changes we see in the American industrial economy may be the natural fruits of maturity. We have produced the world's first "post-industrial" society, with new values, new strategies, new needs, new goals, they said.

Can there be a "change of life" in an economy, a natural stage of growth toward maturity? Charles P. Kindleberger, Ford Professor of Economics, compares the experience of the U.S. with the sequence of "imitation, adaptation, and innovation" in the ascendancy of the British empire over Venice 400 years ago: first the London merchants copied — and badly, at that; then came sophisticated adaptations; and finally came the Industrial Revolution feeding on an outpouring of true British innovation. At last, other nations adopted the same techniques of industrialized manufacture as the British moved on toward maturity. Japan may now be somewhere between the "adaptation" and "innovation" phases, having moved beyond a prosperity based upon simple imitation of western goods.

Professor Kindleberger speculates that the U.S., where (he notes with tongue in cheek) soybeans emerge "as our most dynamic product," may be reaching that stage of industrial maturity typified in England by "tea breaks and long winter vacations." He thinks "our growing lack of commercial morality" is symptomatic of a similar ennui.

Our maturity may be measured in the shift toward what Dr. Wiesner calls "replacement technology" — new technology used not to create major changes in the economy but simply to maintain or modestly improve the status



Automatic control of machine tools was a post-war American contribution to industrial productivity, now widely adopted throughout the world. The photograph shows a sophisticated example of this powerful

technology: a transfer line with automatic machine tools used to fabricate parallel blades from bar stock. (Photo: Westinghouse Electric Corp.)

quo. But a more encouraging manifestation of our post-industrial adulthood is suggested by Jordan J. Baruch, Professor of Engineering at Dartmouth: a growing concern for quality, a rising skepticism about quantity.

If post-industrial society is characterized by ever-larger and more complex industrial units — the unmistakable trend in the U.S. — then it is wholly natural for change in such a society to seem subtle and benign, and for radical innovation to be suppressed, thinks James M. Utterbach of the M.I.T. Center for Policy Alternatives. Companies with established, profitable product lines tend to avoid radical change; they have less to gain and more to risk in expensive, far-out innovations.

### More than Statistics

U.S. productivity is falling, measured in conventional terms as the ratio of industrial output to inputs. John W. Kendrick of George Washington University, one of the foremost students of this subject, attributes our decreasing productivity since the recession of the mid-1960s to seven trends:

- less intensive use of plant due to reduced demand for U.S. products;
- the addition of many unskilled workers (inexperienced women and young people) to the work force;
- inflation which rendered depreciation allowances inadequate;
- increasing “non-productive” expenses to meet new environmental and safety laws;
- the prevalence of antibusiness and anti-establishment attitudes;
- distortions due to wage/price controls;
- reduced expenditures on research and development.

Today’s economic expansion will bring increasing productivity, says Professor Kendrick. But “positive and coherent federal science policy to reverse the declining share of the federal budget going to science” would also help, he says.

Secretary of Commerce Elliot Richardson has a similar view. He cites a series of statistics to prove that U.S. industry’s margin over the rest of the world in productivity, and the rate of U.S. technical innovation as measured by patent applications, “has diminished significantly” in the last decade.

A dilemma here, says Mr. Richardson. If inequalities between developed and underdeveloped countries are to be reduced, then rates of innovation and productivity must be higher in third world nations than in — for example — the U.S. Without such a differential, the rich will grow richer and the poor even poorer.

But this phenomenon, fueled by our export of technology, has put us in the position of being hoist by our own petard, buying the products of our own innovation produced overseas at less cost than we can make them at home.

Mr. Richardson’s prescription, like Dr.

Wiesner’s, is for more technology and more innovation, to provide more exportable ideas, to improve products and their safety, and to reduce environmental impacts.

Another dilemma is made clear by the case of permanent-press clothing, says Professor Baruch. Permanent-press frees housekeepers from steaming ironing boards. If even an hour a week of household labor has been saved, a potential 1.5 million full-time equivalents are added to the U.S. labor force — an enormous increase in the potential productivity of the U.S., but realized, for the most part, only as unemployment.

But predictions of decline in productivity are self-fulfilling. High rates of unemployment and low rates of productivity have certainly inspired insecurity in the students Michael J. Piore sees as Professor of Economics at M.I.T. They relate these difficulties to their own prospects, and as a consequence tend to the “safe” course rather than the imaginative one — afraid to think in unconventional ways, unable to be innovative.

### Knowledge Under Lock and Key

Whatever innovation is and however we value it, we surely need more. Paul A. Samuelson, Professor of Economics at M.I.T., thinks knowledge is like capital: we can never have enough of it. While he has no idea of the nation’s “true absorptive capacity (I don’t even know the ball park we should be in),” he sees “a basic need for public policy to subsidize knowledge.”

Yet neither new knowledge nor innovations can be protected, says Professor Kindleberger. He recalls Britain’s attempt during the Industrial Revolution to prevent the export of plans and machines for steam-powered mass production. It was impossible; workers were tempted by high rewards to take their knowledge to Europe, and their skills as well as their know-how were thereafter lost to Britain. And European countries quickly enough became self-reliant competitors instead of customers. “Ideas, like money and people, cannot be prevented from circulating,” Professor Kindleberger maintains.

“Would a diametrically opposite

## Innovation: More Flies With Honey

Among all the industrial nations, the U.S.S.R. and Japan are at opposite ends of the spectrum. Because of a totalitarian reward system, the Soviets are unable to exploit innovation for productivity. But the Japanese are a major factor in international industry. An extraordinary nationalized program encourages new concepts and devices and transforms them into profits for Japan.

Japan’s successes in innovation and productivity are due to broad government commitments, says Professor T. Dixon Long of Case Western Reserve University; the Japanese research and development budget is unified and the thrust of Japanese innovation is coordinated and even directed by the government. It is “a fundamentally different approach for bringing new technology from laboratories to profitable application,” he told an M.I.T. seminar this spring (see left).

Japanese industrial leaders and policymakers understand that the nation must be “alert to technological innovation wherever it occurs, and that not being first can be the same as not being in the game at all.” The policy “sets a world standard for profitable industrial utilization of innovation,” says Professor Long, and its success should be a warning to all industrial nations.

Though Soviet policymaking is similarly centralized, its results are nothing

short of disastrous. The rate of productivity growth in Russian industry has decreased ten-fold in the last two decades — from 2 per cent per year early in the period to 0.2 per cent per year in the 1970s, says Herbert S. Levin, Professor of Economics at the University of Pennsylvania. The culprit is a reward system which penalizes innovation.

An example of the result, as cited by Professor Levin at a National Academy of Sciences symposium on “Materials and the Development of Nations” this spring: though the U.S.S.R. has become a major steel producer, it still needs \$2 billion more of steel than its mills can produce, because steel is used in the Soviet Union for purposes long since obsolete elsewhere. There has been no substitution of new materials — polymers and nonferrous metals — for steel in the U.S.S.R.

The problem is not lack of effort. Soviet commitments to scientific and engineering education and research are substantial. The problem is an incentive system which rewards managers for performance relative to targets. Managers quickly realize that their success depends on keeping targets low. The more incentives a manager is offered, the more he becomes a barrier to the process of innovation — “a disastrous situation for risk-taking.” — J.M.

strategy be better?" a symposium participant asked of William P. Clements, Jr., Deputy Secretary of Defense. What if we export our research and development achievements so diligently that other nations find their own programs redundant and so lose their own capacity for innovation?

Mr. Clements found that "a wholly new idea" for which he was unprepared — and with which he found little sympathy. He could not envision the Iron Curtain countries, he said, letting themselves be thus hoodwinked into abandoning their capabilities for innovation in national security.

### Alternatives to Laissez-Faire

New environmental, consumer, and safety regulations do not deter American innovation and productivity, thinks Professor Christopher T. Hill of the Department of Technology and Human Affairs at Washington University, St. Louis. He admits there are short-term effects: following federal intervention, innovation in the pharmaceutical industry apparently declined as measured by the number of new drugs brought onto the market. But a proper analysis asks more searching questions: Did the drug companies in fact become more cautious, increasing the ap-

plications of their innovations, if not the gross rate? Did new procedures in fact improve our knowledge, thus increasing the number and efficacy of new drugs finally marketed?

Professor Hill's point, of course, is that if we define productivity broadly enough, environmental and safety regulations can only increase it. "A little bit of falling behind may be the necessary price of cleaning up," says Professor Hill. Later, when environmental safeguards are established everywhere, our position among international competitors will improve because we will have the advantage of a decade or more of adjustment.

U.S. policy toward innovation is in some undefined middle ground between a Keynesian laissez-faire view (in which the role of government is simply to stimulate or depress demand) and the institutional advocacy of the Japanese (*see page 13*), who hold that technological innovation is a primary government responsibility. Should U.S. government be more aggressive? Could it be, if that were our wish?

Industrial innovators are plagued with uncertainty, says Robert G. Gilpin, Jr., Professor of Politics and International Affairs at Princeton — lack of confidence in the innovation itself (will it work?), and in its market (will it sell?). As a result indus-

trial innovators usually invest in short-term research and development that clears the way for government to tackle the riskier jobs which industry cannot justify.

But that course had only modest appeal to most conference speakers. Innovation must be responsive to industrial need, says Professor Gilpin; "identifying needs for innovation is really the name of the game" in the American competitive system. Government intervention would encourage industry to abandon the cautions which are built into the free-enterprise system; we would end up with "a lot of Lockheeds," he says. Indeed, government intervention into energy research and development already threatens that sort of futility, say three members of the M.I.T. Energy Laboratory. Professors Robert S. Pindyck, Martin B. Zimmerman, and Ted R. I. Greenwood oppose proposals for federal guarantees to make possible demonstration synthetic fuel plants. No evidence now available suggests that such plants can produce fuel at costs remotely comparable with fossil prices, they say. True, we need to work on fuel processes, we can hope for a true breakthrough, and we need the best available technology "on the shelf" — ready in an emergency and for routine use at some future time. And the government's proper role is to carry on this research and development — for which industry has no present adequate incentive.

## Energy Innovation: End Run Around the Marketplace?

William A. Vogeley, who was Deputy Assistant Secretary in the Department of the Interior before taking his present faculty post in mineral economics at Pennsylvania State University, says government intervention in energy research and development is circumventing the checks and balances which normally rationalize investments in innovation.

As a result, he told the American Society for Public Administration in Washington this spring, there is serious risk that the U.S. economy will be saddled with high-cost energy "well beyond the time when lower-cost energy will be available to the rest of the world."

Three points of Professor Vogeley's argument:

— The case for the breeder reactor — its development is a major federal effort — rests on the proposition that uranium resources may run out before alternative energy technologies can replace nuclear power. But, says Professor Vogeley, "all of the information available indicates that there are vast quantities of uranium [costing] up to \$100 a pound which could provide, in conventional reactors, relatively low-

cost electricity."

— The U.S. is making large investments in research and demonstration plants to produce synthetic natural gas which may cost \$3 to \$4 per 1,000 cubic feet. Though no one knows how much natural gas remains in world reserves, this price is well above most estimates of its free-market price for many years to come. So he concludes that "to force investment in major coal gasification plants at this time appears to be extremely risky."

— The same argument applies to research and demonstration plants for making synthetic liquid fuels from coal, says Dr. Vogeley. With world petroleum resources "adequate for many decades to come," commitments to synthetics which will cost "in excess of \$15 per barrel" look to him unjustified.

Professor Vogeley admits that there is "great uncertainty" in forecasts of energy supply, demand, and resources; indeed, he bases his argument on that uncertainty: "The private marketplace reacts to uncertainty by not investing, and I would hope that the public marketplace would take the same kind of action." — J.M.

### Understanding Productivity

J. Herbert Hollomon, Director of the Center for Policy Alternatives at M.I.T., agrees that the years since World War II have been "a watershed period" for the U.S. We have learned that there is no automatic transfer of benefits from military research to civilian needs; we have become a strong nation but no longer preeminent; our international favor has been eroded by Vietnam and Watergate; we have learned that the environment can no longer be considered a "free good"; and we have adopted government regulations whose effects are as yet not fully understood.

But nothing in these new conditions suggests to Dr. Hollomon that innovation and productivity are obsolete. We know that successful innovation increases technological capability; but its translation into the marketplace remains mysterious. So our goal in the new post-industrial era must be to understand ourselves and the system in which we work better, he says, so that regulation becomes a positive good, not a self-imposed impediment.

*John I. Mattill is Editor of Technology Review; his report summarizes a conference on "Technological Innovation: Has the U.S. Lost the Initiative?" sponsored by the M.I.T. Club of Washington, D.C., and M.I.T. this spring.*

# Book Reviews

## The Number You Have Reached . . .

*Telephone: The First Hundred Years*

John Brooks

New York: Harper and Row, 1976; xii + 369 pp., \$12.50

Reviewed by Jeffrey L. Lant

Of the several significant commemorations that will occur this year — the defeat of Custer at the Little Big Horn in 1876, the publication in 1776 of both Adam Smith's *The Wealth of Nations* and Gibbons' *Decline and Fall of the Roman Empire*, and, of course, the signing of the Declaration of Independence — one of the most important is the creation of the telephone, "the wondrous invention that changed a world and spawned a corporate giant," as author John Brooks writes.

It was in fact on March 10, 1876, while working at 5 Exeter Place in Boston, that Thomas A. Watson, who had been assisting Alexander Graham Bell throughout his early experiments, heard the distressed voice of his master booming over the crude transmitter Watson had just constructed. Having accidentally upset battery acid over his clothes, Bell's message was understandably curt and to the point, "Mr. Watson, come here, I want you!" The amazing thing was that Watson actually heard him say it and immediately came along.

While the first telephonically transmitted words did not have the grandiloquence and staginess of Samuel F. B. Morse's initial telegraphic message (the celebrated "What hath God wrought?"), they were nonetheless entirely suitable for an instrument whose particular merit has been direct person-to-person conversation, often concerning the need for assistance. In this case, however, Mr. Bell promptly forgot his problem, or as Watson rather laconically noted later, "He forgot the accident in his joy over the success of the new transmitter." In this rather homey, decidedly appealing fashion, the revolutionary invention made its appearance.

As Bell and Watson knew, the importance of their invention was immense. Indeed, it was his recognition of its potential that kept the penurious Bell at work on the telephone despite pressure from his future father-in-law, Gardiner Greene Hubbard, to continue experiments on the harmonic telegraph or risk losing the hand of his daughter, Mabel.

Thus at work on both in the early



Alexander Graham Bell opens the New York-Chicago long distance telephone line in 1892. (Photo: A.T.&T.)

months of 1876, Bell managed to submit his patent for the telephone only hours ahead of his rival, Elisha Gray. As an after-thought, Bell described the crucial variable-resistance mode of sound transmission in the patent's margin; Gray filed a caveat. After having accepted Bell's prior claim, Gray later challenged the Bell patent amid hints by the patent examiner who handled the Bell and Gray filings that Bell's marginal comments had been added after Gray's caveat was entered. The United States Supreme Court in 1888, however, found otherwise, and upheld the Bell patent; it was to be only one of several unsuccessful challenges.

### The Conquering American Hero

Having once proven that sound could be telephonically transmitted, the next problem was to make the invention widely available. Unable to finance its promotion himself, Bell turned to a number of eminent and affluent Boston gentlemen, among them his father-in-law and Thomas Sanders. For a short time both Bell and Watson remained active in the firm that was established. They barnstormed New England giving lectures on the telephone, occasionally to very skeptical audiences. The *Providence Press*, for example, wrote, "It is indeed difficult, hearing the sounds out of the mysterious box, to wholly resist the notion that the powers of darkness are somehow in league with it." Bell and Watson even traveled to England to demonstrate a model to Queen Victoria, who found it "most extraordinary." Ultimately, however, both sold their shares — for a comfortable amount, but not an exorbitant one.

An immediate success, the telephone's

development required a more robust style of leadership than Bell, Watson, Hubbard, or Sanders could provide. Challenged by the likes of Jay Gould and William H. Vanderbilt who were eager to monopolize the invention, confronted by independent operators flouting the Bell patents, and also faced with demands for more and better service, what was needed was an energy, vision, and nerve of the sort which Theodore N. Vail possessed in abundance.

Of the several important presidents of the American Telephone & Telegraph Co., the author is right to concentrate a good deal of attention on Vail, whom Hubbard brought into the American Bell Telephone Co. and who twice held the A.T.&T. presidency. During his first term of office (1885-1887), he was particularly active in combating infringements of Bell's transmitter patent, as well as the depredations of those who wished to absorb the company.

He also set about creating an organization strong enough not merely to survive, but to dominate the telephone market once the key Bell patents expired in 1893 and 1894. In all these areas he was brilliantly successful, though in achieving his success he affronted the more conservative New Englanders who still controlled the company and who were unwilling to make the huge capital outlays Vail thought necessary to improve service and maintain commercial supremacy. So in 1887, he retired from the presidency, to be succeeded by a series of less colorful, more cautious men.

But his retirement from the company was not permanent. During the years of conservative management, the independent operators came close to splitting the telephone market with Bell; by 1907 there were about 3 million Bell telephones in operation and nearly as many independent ones. Faced with this situation and desperately needing large amounts of capital to expand, the Boston clique which had ruled the company from its inception reluctantly turned to the powerful Morgan banking interests for support.

J. P. Morgan, anxious to consolidate all the American telephone and telegraph systems, was willing to help, but he demanded a change in management; once more Vail was brought in to be president, this time staying on from 1907 to 1919.

### Securing Empire

The second Vail presidency constitutes a watershed in the history of A.T.&T. Beginning with a deliberate monopolistic policy and backed by Morgan money, Vail set out to absorb as many independent operators as possible, and also to dominate the telegraph industry. In both areas he enjoyed his usual success. For example, Western Union, which had once been near a position to absorb American Bell, was itself taken over by A.T.&T., with Vail as its president and the head of

an interlocking Western Union-A.T.&T. directorate.

However, when it became clear that the public was becoming affronted by Bell's occasionally heavy-handed tactics and that the challenged independent operators were persuading the Justice Department to launch an antitrust suit, Vail reversed the company's policy. In December, 1913, by the so-called "Kingsbury Commitment," A.T.&T. undertook to dispose of its holdings in Western Union, purchase no more independent telephone operators except with the permission of the Interstate Commerce Commission, and allow the independents to use the lines of the Bell system.

Although some might offer a more cynical interpretation of Vail's self-denying ordinance, John Brooks calls the "Kingsbury Commitment" an act of business statesmanship. From it, he formulates a standard of sensible, reasonable, and far-sighted executive behavior against which all subsequent managerial decisions of A.T.&T. are evaluated.

In this way, Brooks commends the company for divesting itself of holdings later accumulated in radio, films, and satellite communications, since such activities detracted from its primary concerns and would have increased pressure to break the monopoly into a number of smaller companies. He also condemns it for the policies which led to the disastrous service failures in the late 1960s, the

result of a deliberate decision which took profits from service costs. In all, Brooks' seems a fair enough standard by which to judge A.T.&T., and Vail enough of a model executive to make that standard cogent.

Indeed, Brooks' entire approach is equitable. Having secured complete and unhindered access to the company files (it would have been interesting to know how he made his selection of documents from the nearly 20 billion pieces of paper in them), he has produced a book which is instructive and which will probably please A.T.&T. In any event they have ordered a sizeable number of copies for widespread distribution. By the same token, those who might have hoped for a more caustic result will be disappointed. The book is utterly without revelations. There is a little judicious criticism of some policies, to be sure, but it is more than balanced by considerable praise.

No doubt much of this praise is due. While other giant corporations have grown sluggish and intractable in their old age (most are in fact younger than A.T.&T.), the telephone company has generally kept pace perhaps, as Brooks speculates, because it is closest to the consumer and most responsive to his needs and demands.

*Jeffrey L. Lant holds the Ph.D. in History from Harvard, where he is an Affiliate of Dudley House.*

## Salisbury

Continued from p. 8

the urgency of a higher priority for studies of basic marine ecology.

"All my means are sane, my motive and object mad," said Captain Ahab of his search for the white whale. Many marine environmental assessments seem to make about as much sense as Ahab's quest, and could have as disastrous a result. Doing "baseline" studies without attempting to interpret them may fulfill the letter of the law, but not its spirit.

In the May 7 issue of *Science*, D. W. Schindler, Leader of the Experimental Limnology Project at the Freshwater Institute in Winnipeg, editorialized: "Many politicians have been quick to grasp that the quickest way to silence critical 'eco-freaks' is to allocate a small proportion of funds for any engineering project for ecological studies. Someone is inevitably available to receive these funds, conduct the studies, . . . [and] write large, diffuse reports with reams of uninterpreted and incomplete data. . . ."

According to Dr. Schindler and other ecologists, the poor quality and rustic techniques used by many "environmental engineers" make their work of little scientific value, despite the enormous sums of money spent on it. Now James Liverman of the Energy Research and Development Administration (E.R.D.A.) is assembling an oversight committee for energy-related environmental studies carried out by all federal agencies. Although E.R.D.A. is devoting only one per cent of its total budget to environmental work, the scientists involved consider their approach enlightened. So we may hope this committee will have positive effect. The fate of the oceans may hang in the balance.

*David Salisbury is Science Editor of the Christian Science Monitor and a regular contributor to Technology Review.*

## PROFESSIONAL ENGINEERING FOR CAPITAL EXPENDITURE PROGRAMS

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## Oberg

Continued from p. 11

the payoff in unlimited pollution-free electricity makes it worth investigating.

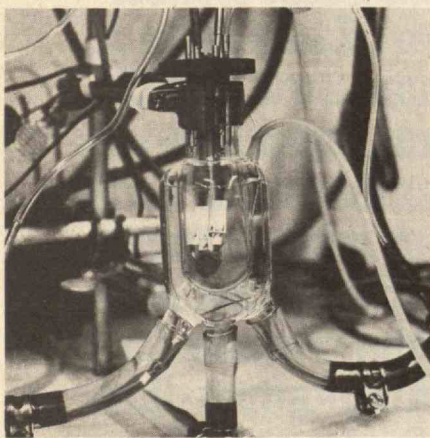
The space era which the Skylab and Salyut flights have opened is only beginning. After initial voyages of discovery, men are returning to space for extended periods to live and work, as they returned to Africa, the Arctic, and the American West in years past.

*James E. Oberg is a computer specialist in the Space Shuttle Project in Houston.*

## Notes on Current Research

### Freezer for Transplant Organs

A new apparatus built at M.I.T. for preserving (by freezing) organs to be placed in a "transplant bank" is now being tested at Massachusetts General Hospital. The goal is an elusive one, since even the most precise temperature and environmental controls may by themselves be inadequate to manage the many variables involved. Michael G. O'Callaghan, a graduate student, and Professor Ernest Cravalho of the Department of Mechanical Engineering have designed the new apparatus especially for preserving rat hearts; at least three years of work to verify computer-based analytical studies are ahead before they are ready to attempt the ultimate test: freeze a rat heart, preserve it, thaw it, and transplant it into a second rat.



The dark object in the center of this complex glass flask is the heart of a rat, in the process of being chilled to freezing temperatures in an M.I.T. research program on the preservation of vital organs for transplanting. After a year's work in a program sponsored by the National Heart and Lung Institute, Professor Ernest Cravalho and Michael G. O'Callaghan have succeeded in preserving hearts cooled almost to freezing for hours or even days; a frozen heart might be saved for weeks or even months.

### Magnetospheric Plasma Sensor

A hardy but sensitive instrument which will measure and report the magnetic particles and fields surrounding Jupiter, Saturn, and Uranus is now nearing completion in the Center for Space Research; it will be one of 11 scientific experiments aboard N.A.S.A.'s Mariner spacecraft to be launched toward those planets in August, 1977.

Jupiter's magnetosphere is known to be both intense and large, but the M.I.T.-designed instrument will be the first to directly observe the velocity, temperature and density of the plasma trapped in the planet's strong magnetic fields. Little is known of the other two planets' environments. The plasma instrument will also measure the increasingly rarified solar wind as the Mariner moves toward the fringes of the solar system.

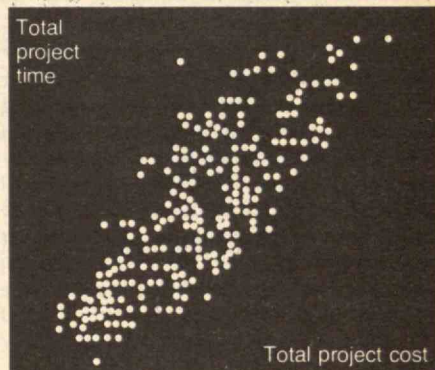
The new instrument is 10 to 20 times more sensitive than earlier plasma detectors, and it is designed to operate for at least the five to eight years which will be required for the journey to the three planets. Protection from extremes of temperature and from the intense radiation of Jupiter have been the most difficult problems, says Robert J. Butler, Project Manager.

### Male Chauvinism at Home Here

What's wrong with "gritty-nitty," "beast and man," "woman and man"? Nothing, except that nobody says it that way. "Man and beast," "nitty-gritty," and "man and woman" are what linguists call "freezes" — short patterns of words whose sequence is based on habit, not on logic. According to the "me-first" principle of Professors John Robert Ross and William Cooper of the Department of Foreign Languages and Linguistics, the word with fewer syllables and short vowels comes first, and so does the word which is most clearly identified with an adult male. So it's "father and son," "Adam and Eve," say Professors Ross and Cooper, and they conclude that male chauvinism is in fact part of the language, the result of unconscious processes which may be beyond feminists' reach — at least for the present.

### Computing the History of Mars

The seismic data collected as the Viking spacecraft plops down on the surface of Mars this summer will be put into an M.I.T. computer for interpretation. Professor M. Nafi Toksoz and his assistant, David H. Johnston, have supplied the computer with a model of Mars' geophysical history, including the evolution of both its interior and mantle. As Viking's seismographs report tectonic features, the computer will help the scientists seek a consistent interpretation.



For each simulated tunnel for which it is provided site data, a new computer-based Tunnel Cost Model developed in the M.I.T. Department of Civil Engineering shows estimated costs and construction time — "a distribution of costs and project durations representing the combined effects of all identified sources of uncertainty," according to Professor Fred Moavenzadeh.

### Tunnel Estimator

A computer-based system for estimating tunnel construction costs, developed in the M.I.T. Civil Engineering Department under sponsorship of the RANN Program of the National Science Foundation, is now available for commercial use.

Advantages, says Professor Fred Moavenzadeh: the model treats explicitly many "major uncertainties" in tunnel construction; and its speed and level of detail make it "ideally suited" for evaluating alternative tunnel locations and methods of construction.

# Trend of Affairs

## Trends This Month

### NEW TECHNOLOGY

19

Consider the moveable press . . . the sound of one crack propagating . . . the hidden abilities of your pocket computer . . . or the inscrutability of information machines.

### ECOSYSTEMS

20

The cash value of organic energy . . . the regional accents of songbirds . . . and the optimization of agro-systems.

### MATERIALS

22

The choice between free-flowing rivers or free-flowing coal . . . The never-ending struggle between haves and have-nots on an international scale.

### HEALTH

24

Economic recession engenders physical depression.

The Gutenberg Bible contains a lesson for all engineers who would design new products. Standards for a new technology are not necessarily rational; they are heavily skewed to what went before, says Frank Romano, a consultant on new technology for the graphic arts industries. Gutenberg's goal was to replicate calligraphy; the page reproduced here demonstrates that Gutenberg did not take the best advantage of his new technology of moveable type for the purposes of its readers.

**S**icut fuscillā iunco tegetem  
aut palmarū folia compli-  
carem aut in sudore vultus  
mei comedere panem. et  
ventris opus sollicita mēte pertrada-  
rem: nullus morderet nemo reprehen-  
deret. Nūc autē quia iuxta sententiam  
saluatoris volo operari cibū qui nō  
perit et antiquā diuinorū voluminū  
viam sentibus virgulisq; purgare:  
error michi geminus infigitur. corre-  
ctor viciōs falsarius vocor. et errores  
non auferre sed serere. Tanta est enim  
vetustatis consuetudo ut etiā confessa  
plurimq; vicia placeant: dū magis pul-  
cros volūt habere codices quā emen-  
datos. Quapropter o fratres dilectis-  
simi unicū nobilitatis et humilitatis  
exemplar et pro flabello calatis spor-  
tellisq; mimusculis monachos. spiri-  
tualia hec et mansura dona suscipite:  
ac beatū iob qui adhuc apud latinos  
iacebat in stercore et vermibus scatebat  
error. integrū et immaculatūq; gaude-  
te. Quomō enim post probationem  
atq; victoriā duplicia sunt ei uniuersa

## Putting Computers in Medical Instruments

Can the tiny logic elements in today's hand-held calculators and computers be applied in medical instruments to give doctors information they need more quickly, and in more useful form?

Dr. Roger G. Mark, Associate Professor of Electrical Engineering at M.I.T. and Assistant Professor of Medicine at Harvard Medical School, is a believer. He directs a new Biomedical Engineering Center for Clinical Instrumentation under a \$1.016-million grant to the Harvard-M.I.T. Program in Health Sciences and Technology, and the result is likely to be a wholly new

class of medical instrumentation. The idea is to obtain diagnostic data by building computers directly into instruments:

— A wearable computerized monitor for detecting irregular heartbeats.

— New instruments for diagnosing the causes of dizziness and disequilibrium.

— A probe to measure blood flow through tissues, and to monitor patients' condition during surgery.

— An instrument to collect and process data on respiratory function, useful especially for studying dynamic events such as occur in asthma.

### NEW TECHNOLOGY

## Technology Backset

The type in the headline above this item is "kerned," and therein lies a lesson for engineers who would design products that will succeed in the market for quality goods.

Consider Gutenberg and his contemporaries: their goal was to make moveable type look — as much as possible — like the calligraphy which preceded it. By the time the Linotype was invented, handset type had become the standard of quality to which Linotype's designers aspired. And when modern electronics was brought into typesetting, engineers went out of their way to duplicate, as nearly as they could, the esthetics of Linotype and Monotype — despite the fact that their electronics opened up new opportunities for flexibility and efficiency in letter forms and their assembly.

Our standard of quality "has always been what went before," says Frank Romano, a consultant on typography and computer-controlled typesetting. "And quality is whatever you are willing to pay money for," he told Boston's Society of Printers this spring.

What about "kerning"? "Kerning" is the effect achieved when a letter following an overhanging letter is set under the overhang, as — for instance — the "e" following the "T" above. That effect is natural in calligraphy, fairly easy to manage in movable type, impossible with Linotype, and possible but not always easy with electronic typesetting such as used by *Technology Review*. Mr. Romano says that among "typofiles" automatic "kerning" is now "the most important single measure of typographic quality" — an esthetic regression to Renaissance calligraphers. — J.M.

## Noisy Faulting

When a steel beam is stressed, it often makes a tiny, characteristic sound — an acoustic emission (A.E.). The same thing seems to happen in many materials under

many different conditions — phase transitions, crack propagation, and stress corrosion. For obvious reasons, A.E. is regarded by optimists as a promising new means for monitoring structural integrity and even for nondestructive testing.

A new field — perhaps 150 engineers working in the U.S. and about as many in Europe — was formalized for almost the first time at a meeting sponsored by the British Institute of Physics last fall. But A.E. is full of uncertainties. No one seems to know how crack propagation in steel, for example, produces an acoustic emission, or even if it does so consistently. The emissions are weak — extraneous noise is often larger than the signal one seeks. Oil dropped into a propagating crack silences the A.E. At peak load, a beam with a crack in it emits a continuous A.E.; at minimum load, it emits discrete pulses.

In a longer account of the meeting and of A.E. in *Engineering and Scientific Notes* published by the London branch office of the Office of Naval Research, T. A. Kitchens wrote "Someone in the audience facetiously asked if A.E. surveillance systems were being planned for the North Sea oil platforms, and someone else in the audience was, in fact, looking into it. But there were many environmental noises, such as barnacles and lobsters, with which to contend." — J.M.

## Only the Calculator Knows

That little electronic sidekick you use to figure your bank balance or unravel an equation has many more capabilities than you, or the manufacturer, know. The average programmable calculator owner uses only about 40 per cent of his or her machine's possible capacity. The remaining 60 per cent lies fallow simply because the information is not readily available, say engineers Dean A. Lampman and Richard J. Nelson.

What's more, the manufacturer will probably remain lax about keeping calculator users in the know, because of

conflicts of interest, cost, ability, and the N.I.H. (Not Invented Here) factor. The users themselves will have to generate underground, or overground, networks to keep one another up to date on calculator capabilities.

Messrs. Lampman and Nelson, speaking at the May meeting of the Institute of Electrical and Electronics Engineers in Boston, concentrated on the "super calculators" — those programmable pocket-wizards manufactured by Hewlett-Packard and Texas Instruments. These calculators have sophisticated storage and calculating capabilities, and some allow complicated programs to be stored on small magnetic cards.

The average programmable calculator user soon comes to suspect that his calculator has more to it than meets the fingertip, and soon wonders what else the manufacturer hasn't told him about the calculator, they said. He not only discovers neat programming techniques that can plow through calculations faster, but also special features of the hardware itself that the manufacturer either couldn't or wouldn't advertise.

Among the surprises are new ways to have the calculator generate random numbers, ways to have constants quickly calculated rather than stored, and better methods for juggling numbers and commands in the calculator's memory.

"The manufacturer cannot be a source for the best programs because the situation of an employee being assigned to write programs cannot provide the ... environment for passionate involvement. Rarely is the motivation as powerful as it is for the user writing a difficult program on his own time for his own use. How can the company compete with the brilliant minds of tens of thousands of users?" ask the engineers.

The harried manufacturer must cope both with the beginner just learning his machine and the pro who solves problems even the manufacturer doesn't understand. And good news to the owner — like how to make his programming cards cheaper — is not always good news to the manufacturer trying to sell programming cards.

All in all, even with the programming libraries which manufacturers are developing, it will always be the user's job to know his calculator, say the engineers.

"... It seems that the user will always be limited to about half power from his machine if he depends solely on the manufacturer for his applications support." The engineers applaud such organizations as the "HP-65 Users Club" for owners of the Hewlett-Packard product, and issue a clarification for more newsletters, books, and pamphlets for and by users. — D.M.

## Shaping Computers for an Information Age

Though no one can assign a price, information is clearly a valued commodity in today's world — the subject of capital investment, operating expense, inventories, research, conversion, transportation. But as a commodity, information is unlike grain, steel, or even books. It has some very special frustrations.

Our insatiable appetite for information makes it unique in today's world, Professor Thomas B. Sheridan of M.I.T. points out: when we know a little about a subject or interrelationship, we are almost surely curious to know more. The more we know the more there is to know, and we have devoted major resources to this compulsion. Frank L. Bernstein, Vice President of Auerbach Associates, Inc., management consultants, says "Our society literally can be defined in terms of its high level of information activity. Ours may, in fact, be the first 'information society.'"

But the human brain, despite a truly remarkable data processing capability, has a finite information capacity. If information comes to the brain too fast or in too great complexity for storage or processing, it is lost, irretrievable.

The conflict is clear. The more information we have, the more we want and the less our capacity for it — a fundamental frustration, a perverse mismatch that brings visions of senility to the most inquisitive minds.

Hence our growing dependence on computers as processors of information — and our growing desire to make information which we put into computers easily accessible when we need to retrieve it.

Robert M. Fano, the founder of M.I.T.'s Project MAC (Machine Aided Cognition), has a different vision of information. Emphasize computers which provide knowledge — including "common sense," — not machines that merely store and process information, he says. Let them be more monolithic, at least from the user's perspective, so that a single query will bring to bear whatever capacity is pertinent for the answer. And let them be

widely accessible, easy to use.

Such machines, he says, are the first steps along the way to a truly effective "information society." Existing computers have skills comparable to those of a mathematician — they can do "substantial mathematical problems on request," and they know more than any single mathematician today. But mathematics is a highly structured system of knowledge; we're a long way from having machines that understand as much about such intuitive, unstructured disciplines as management and medicine.

Accessibility is essential, too. Today we have a single telephone system, making all its communications power available to all, a public system, a threat to no one, a system which respects the balance of power in society, says Professor Fano. Consider, in contrast, the private systems of radio: police radio, taxi radio, broadcast radio, amateur radio ... They breed division and jealousy, users of one threatening users of another.

Will tomorrow's monolithic information system, composed of interconnected computers possessed of intelligence, common sense, and an almost infinite capacity for information, become man's master instead of his servant?

The wrong question, Professor Fano told the American Association for the Advancement of Science last winter in Boston. The real danger lies not in a future system's size and power but in its *apparent* complexity, its inscrutability. The question is, can we all use it? And can we understand it well enough to be sure it is answering the question we intended to ask? — J.M.

### ECOSYSTEMS

## Pricing a Swamp

A western-style free economy demands that a cash value be put on everything; an unpriced esthetic value is an anachronism with which the system is unprepared to deal.

Hence the effort of Eugene P. Odum, Director of the Institute of Ecology at the University of Georgia, to calculate monetary values for preserved marshlands and estuaries of the South Atlantic and Gulf Coasts. Three bases are used:

— Fishery nurseries, computed by dividing the values of fish and shellfish landed on these coasts and of sport fishing by the number of acres of estuaries which provide the nursery grounds for these harvests. The answer is an annual return of about \$100 per acre.

— Aquaculture potential, based on oyster harvests at the Bears Bluff Laboratory, South Carolina, just over \$2,200 per acre per year.

— Waste treatment value, calculated from the costs of secondary and tertiary treatment in man-made plants. An average es-

tuary can assimilate a B.O.D. loading of 3.5 pounds per day per acre, says Dr. Odum, and many are in fact assimilating far more than this; in addition, "very large amounts" of phosphates can be assimilated because, with vigorous tidal action, an active estuary system "stores and recycles nutrients with great efficiency." By Dr. Odum's calculations, an acre of tidal estuary substitutes for a \$75,000 waste treatment plant; at 5 per cent interest, that's an annual return per acre of over \$3,700.

Not all these uses are consistent, so Dr. Odum and two colleagues — James Goswami and R. M. Pope of Louisiana State University — propose a total annual return of \$4,100 per acre of marshland and estuary; that's equivalent to the return at 5 per cent interest on \$82,000 — "what man would have to pay if the estuary were not available to do his work free," says Dr. Odum. — J.M.

## Spring Sing

Spring is a season of miracles: from seeds come roots, leaves, and presently flowers; from pupae come insects which proceed to eat, migrate, and reproduce by some hidden directives precisely as did their ancestors; from winter quarters come birds — even tiny hummingbirds — across vast continents and oceans to rear a new generation of offspring in the very places of their parents' birth.

It is the most dramatic of seasons, a time when uncounted mysteries unfolding around us move scientists — and the rest of us — from laboratory to field. Minor mysteries may yield to this annual scientific assault, but ultimate mysteries do not:

Masakazu Konishi of California Institute of Technology finds that most songbirds sing in regional dialects learned from their elders and indeed are dependent on their parents to teach them the song which is characteristic of their race. A white-crowned sparrow raised without his parents develops a confusing repertoire never heard in nature; if he hears a tape-recorded dialect in place of his parents' song, he mimicks the song he hears. Not so a dove: he is born with his vocal repertoire, and no lessons are needed. If we can somehow understand how birds learn songs, can we better understand how a child acquires speech?

Are birds monogamous? Some species — geese and grouse, among others — mate but once, permanently. But many songbirds — at least the most successful, aggressive males — are polygamous. Michael Carey and Val Nolan, Jr., of Indiana University conclude that male indigo buntings in the prime of life choose the "best" territories — ample food, good cover — and females crowd around these choice sites. Monogamy rules in less attractive areas. All this sounds logical

enough; but by what instinct does the inexperienced female in her first breeding season behave in such a rational way?

Finally, consider the bird whose territory is threatened. Thomas Patterson, Lewis Petrinovich, and Harmon V. S. Pecke of the University of California (Riverside and San Francisco) played recorded white-crowned sparrow songs in territories claimed by other white-crowned sparrows. The resident birds recognized the recordings as threats from unknown competitors, but the nature of their response depended on their stage in the breeding cycle. A male whose female was brooding eggs responded strongly, the male with fledged young was agitated but circumspectly quiet. The psychologists' conclusions: "... the response to song is determined by a complex interaction in which internal states may influence the intensity of the response system of both males and females, and the stage of the reproductive cycle influences the response typography." — J.M.

## U.S. Protein Sources: A Belt in the Breadbasket

If this country is the world's grocery store, it's more by chance than by choice. We'd best do some planning if we are to keep the business going.

These plans must include research on exploiting new protein sources and understanding old ones, according to a study released last December by M.I.T.'s Department of Nutrition and Food Science. The study, "Protein Resources and Technology: Status and Research Needs," directed by Nevin Scrimshaw, Head of the Department, and Biochemical Engineering Professor Daniel I. C. Wang, drew contributions from over 2000 experts in food and nutrition.

Agricultural research in this country is fairly well-to-do — receiving about \$1 billion of support per year, the study pointed out. However, this money goes for a head-down, bulling forward, conventional sort of research which ignores some basic needs and does not allow exploratory stabs at developing unconventional protein sources.

For one thing, nutritionists aren't sure how much protein is needed to maintain health. According to the study, new basic research must determine human protein needs at all ages as well as how they are met by various protein sources. Methods to determine the safety and quality of new protein sources must also be improved.

To avoid putting all the research eggs in one basket, the report urged funding research to:

- Allow food crops to fix their own nitrogen from the air, reducing fertilizer needs;



The U.S. grows more wheat each year than it can use. Such productive abilities should be pushed much further if the world is to be fed. New strains of wheat, screening methods to identify the protein-rich strains,

and full use of wheat by-products all must be developed, says the M.I.T. report on agricultural research needs. (Photo: Stock, Boston)

- Separate and modify proteins from leaves, low-cost cereal grains, legumes, and oilseeds to build acceptable new foods, such as artificial meats;

- Develop sanitary technology for reclaiming leftover livestock muscle and organs, defective poultry, and damaged eggs, now rejected for human use;

- Recycle the mountains of cattle wastes for cattle feed;

- Investigate new ocean food sources, such as Antarctic krill and "trash" fish;

- Use algae, single cell protein, etc., for human food; and

- Develop novel plant breeding methods to produce more productive crops.

One study author termed such exotic protein sources "gee whiz" foods; the study recognized that barriers of consumer acceptance and traditional federal Food and Drug Administration opposition to new protein sources must be confronted.

With this study, U.S. agricultural research receives another carefully aimed punch, following closely the study by the National Academy of Sciences, "Enhancement of Food Production for the United States," released last November. That study pointedly criticized the quality and structure of the huge agricultural research system, reporting that research on unconventional protein sources and basic agricultural science has been badly neglected. The N.A.S. report also proposed a reorganization of Department of Agriculture missions so that research would receive more emphasis and would be overseen in the department by a scientist. It called for an increase in U.S.D.A. research funds of 40 per cent; and, like the M.I.T. study, called for additional funds — \$110 million — from various agencies for basic and unconventional research. — D.M.

## Plenty of Water for Western Coal?

At least 68 billion tons of coal lie within reach of strip mining in the Fort Union formation spanning eastern Montana, northern Wyoming, and western North Dakota, and another 173 billion tons — 1,000 feet or more below the surface — await deep miners. It is a land of modest, seasonal rainfall, of spring floods and summer droughts. There may not be enough water for the development of this immense energy resource.

Strip mining and rail transportation of coal bring with them minimal water demand. But developers talk of shipping coal in slurry pipelines and converting it on-site into gas or electricity, and then water supply becomes a critical issue. "There is sufficient water for any foreseeable energy development in the northern Great Plains," said Theodore T. Williams, Head of the Department of Civil Engineering at Montana State University. But development plans are being promulgated at a "staggering pace," he told the American Society of Civil Engineers annual meeting in Denver last fall. He and his neighbors, accustomed to a land of "free-flowing rivers loaded with trout," find all this "overwhelming and even frightening."

To transport 1 million tons of coal a year in a slurry pipeline requires water at the rate of 1 cubic foot per second — 20,000 acre-feet of water will move 25

million tons of coal. A 1,000-megawatt steam-electric plant requires 15,000 acre-feet a year for evaporative cooling, or if a dry cooling tower is used, 2,000 acre-feet a year. Some 30,000 acre-feet of water may be needed by a plant producing 250 million cubic feet a day of synthetic natural gas from coal.

How much water is available? The Fort Peck reservoir on the Missouri River in Montana contains 18 million acre-feet. An average of 500,000 acre-feet flows past Sydney, Montana, in the Yellowstone River every February, 2.5 million in June — in a full year, 8.8 million acre-feet more than present users require. There are also "substantial" volumes of ground water; one 60-year-old well in Wyoming yields more than 4,000 gallons a minute.

If annual coal production reaches 1 billion tons a year by 2000 — that's the highest of a series of estimates by the cooperative Northern Great Plains Resource Program — water demand may be as much as 800,000 acre-feet, half for coal conversion, one quarter for slurry pipelines, and one quarter for other activities which energy developments will attract.

In absolute terms, even in dry years and even considering other unrelated increases in water consumption, there's far more than 800,000 acre-feet of water now surplus in the northern plains.

But that simple statement is not at all an answer to the question, thinks Professor Williams. Some very significant uncertainties remain: what will be the effect on

existing water users of the depleted streamflows? What effect on fish and wildlife? Many coal seams are aquifers: what will happen to ground water as the coal is mined? What about new reservoirs on lands that could otherwise be mined or farmed?

These are "conflicts of major proportion," says Professor Williams; "no one knows how they will be resolved." — J.M.

## The International Jigsaw

You are the King of Jolliginki (Jolliginki — remember? — is the African country where Dr. Dolittle and his menagerie were jailed because Europeans were slavers and plunderers). You learn that under the ocean 1,000 miles north of Samoa, more than 10,000 miles from Africa, there lies the richest known deposit of deep-sea nodules full of nickel, copper, and manganese. And you learn such nodules — not all as rich as these — form in the Pacific at the rate of 10 million tons each year, accumulating metals on the bottom of the ocean faster than the world is consuming them.

So you outfit your Foreign Minister with two Brooks Brothers suits and pack him off to New York City. The Jolliginki Mountains contain rich, undeveloped deposits of copper and nickel, and you want the United Nations to keep the seas inviolate so western technology will not overlook your copper.

But within a decade after western exploitation of your copper and nickel begins, a new problem begins to plague your Minister of the Interior: you are running out of a depleting resource and your treasury has little money to show for it. Most of the mining royalties have been absorbed by inflation or spent for oil. She wants you to mobilize the army to nationalize the mines and smelters.

### Materials Dictate History

Materials have been a source of international tensions since nations began. Rapidly increasing world consumption, leading to fears of depletion and calls for limits to growth, have brought us to what Lord Ritchie-Calder calls "a climacteric period in history" dictated by materials.

"Today materials dominate international relations. They underscore more clearly than anything else the interdependence of nations," he said. Lord Ritchie-Calder spoke at the opening of a symposium arranged by the National Academies of Science and Engineering to emphasize the urgency of international understandings about materials and their management.

Conference participants presented four points of view. Rafael Sandrea of Ven-



The West contains enough water to process and convert 1 billion tons of coal a year, says Professor Theodore T. Williams of Montana State University, but priorities are a crucial issue. According to an analysis of

U.S.G.S. estimates by M.I.T.'s Ronald F. Probst, a plant producing even 1 million B.t.u.s of "pipeline-quality" gas or synthetic oil would require as much water as a city of 250,000. (Photo: Burlington Northern, Inc.)

## International Taxes?

Should any one nation lay claim to the fish in the world oceans, the nodules on the sea bottom, the oil under the continental shelves distant from land, simply because it possesses the capital and technology to exploit them?

Tensions between developed and less-developed countries feed on questions such as this. To ease them Professor Richard N. Cooper of Yale University proposes a system of international taxes.

Let every international fishery be supervised by a regional commission and pay taxes on its harvest, he told a workshop on "The New International Economic Order" in the M.I.T. Department of Economics this spring; let a substantial share of revenues from the exploitation of oil found in waters 200 or more meters deep be set aside for interna-

tional uses; let those who would mine nodules bid for mining rights and/or pay taxes to an international authority on the basis of the profits they reap.

Such a system of royalties and taxes could yield perhaps \$2.2 billion each from fish and oil by 1985, \$100 million (based on a 50-percent-profits tax) from manganese nodules. That's an annual total of \$4.5 billion — "a magnitude that deserves serious consideration," Professor Cooper said. Placed in the hands of the international community through disbursal by such agencies as the International Development Association or regional development banks, said Professor Cooper, such a fund would represent "a major opportunity for mankind to build toward a world community." — J.M.

ezuela's Foundation for Petroleum and Petrochemical Research describes his country's dilemma: rapid industrialization, with imports growing at the rate of 7 per cent a year, imports of raw materials increasing 10 per cent a year, of heavy equipment 14 per cent. More than 60 per cent of the money paid to Venezuela for oil goes right back into the coffers of the oil-buying nations — "a cycling effect of draining the capital generated by depleting our natural resources, . . . an economic fiasco [from which will develop] intolerable social consequences in the near future." Hence Venezuela's new policies: development by the state of capital-intensive industries, and a tax on all industrial sales to finance an "aggressive" national research and development effort.

An underdeveloped nation without Venezuela's income from natural resources is in a still more difficult circumstance. The gap between rich and poor has widened: economic growth in developed countries has mushroomed since World War II, and the rising cost of O.P.E.C. oil will make it ever more difficult for underdeveloped countries to catch up.

Can technology help? Most such underdeveloped nations have a well-developed enmity for technology; they've tried it and haven't liked it, says Ronald D. Ridker of Resources for the Future, Inc. They've received new seeds for new plant varieties presumably more productive than the old and seen the new plants succumb to pests to which indigenous plants were resistant. Like the King of Joliginki, they want foreign capital to exploit resources and develop industry. But consumer goods — including food —

are so scarce that foreign capital is usually absorbed by inflation, a cause of social disruption.

There is a limit — a low one — on the possible rate of growth of such an economy, says Dr. Ridker, and foreign technology is no panacea unless it is applied with a sensitivity for local constraints.

### Price Supports or Trade Restraints?

Four relatively developed and resource-rich nations — Canada, Australia, New Zealand, and South Africa — have special priorities, topped with a desire for a more stable world market with dependable demand and price, and without tariffs and other artificial barriers to trade. Their spokesperson, Professor Stuart Harris of the Australian National University, condemns the U.S., for example, for farm price supports which artificially reduce the amount and raise the price of U.S. wheat. Or consider Japan, whose policy is to diversify the sources of her raw materials as protection against high prices and embargoes. "Sound business practice," admits Professor Harris; but "should such 'price-depressing' actions be internationally acceptable?"

What of the U.S., perhaps the world's only mature, developed economy which is still resource-rich? Charles W. Robinson, Deputy Secretary of State, brings a gloomy prognosis across the street from the State Department to the National Academy of Sciences: a worldwide recession has meant reduced consumption of many basic materials, leading to surplus capacity and economic hardship for the industries and nations supplying those materials. Now the recession is ending,

demand will return to normal, productive capacity will be insufficient, and prices will go up. And they will stay up. "Political risk is clearly a major deterrent to resource investment today," says Mr. Robinson. The political problem of how to manage "tension between economic interdependence and political independence is paramount."

### A Microeconomic Understanding

How to reconcile so many contradictory concerns?

Says J. Herbert Hollomon, Director of the Center for Policy Alternatives at M.I.T., "You cannot discuss materials without discussing the world, and you cannot plan in the materials field in one nation without planning for the world." And if this difficulty overwhelms you, consider this: we are now supply-limited, at least in the case of some materials, so we have to deal not with materials in general but with specific materials — copper, cobalt, lead, chromium, whatever. This means that we must achieve a microeconomic (not a macroeconomic) understanding of the system.

Further, says Dr. Hollomon, we must ask whether the economic decision-making system of the industrialized world (which Dr. Hollomon characterizes as "one dollar equals one vote") can in fact fairly treat the less developed countries.

The need, he says, is for "a massive effort to understand the interconnectedness of environment, materials, the economy, transportation . . ." — J.M.

## Government and the Aluminum Problem

The U.S. produces one-third of the world's aluminum, and 90 per cent of the ore we use (bauxite) is imported, mostly from Jamaica. Now the bauxite-rich nations of the world have formed the International Bauxite Association, and the U.S. Bureau of Mines has given new priorities to a 50-year-old program for finding how to obtain aluminum from nonbauxitic resources which are available in the U.S. It is a classic case of a government intervention in response to an anomaly in the resources market — just what M.I.T. Professor Robert M. Solow says should occasionally happen.

Bauxite is about 50 per cent alumina ( $\text{Al}_2\text{O}_3$ ), the basic aluminum ore. Nonbauxitic sources average 25 to 35 per cent  $\text{Al}_2\text{O}_3$ . No amount of technology can overcome that difference, which implies the need to handle more material and use more equipment and capital to win aluminum from nonbauxitic materials. The nonbauxitic refining processes are more complex and involve corrosive materials and they require perhaps twice as much energy as is needed to produce aluminum from bauxite.

There is no shortage of nonbauxitic raw materials in the U.S. But despite intensive research and pilot plant programs, it is still not possible to predict which processes based on which ores will ultimately prove most promising. No one expects any alternative to be economically competitive with processes based on imported bauxite. But that is not the point, engineers from the U.S. Bureau of Mines told the American Mining Congress: "The knowledge that a technically proven process exists will set a ceiling on bauxite prices and serve notice on producers that the U.S. could, if necessary, satisfy its needs for alumina from its own resources."

If nonbauxitic processes are not competitive, how shall the U.S. proceed with their development? A suggestion from J. Herbert Holloman, Director of M.I.T.'s Center for Policy Alternatives: Let the government commit itself to buy all pilot plant domestic alumina production at a specified, guaranteed price. The contractor's incentive to create an efficient plant at least cost will be preserved; he shares both risk and profit. — J.M.

## Wood Fuels Wood

If his forests are like most of those in the tropics, the King of Jolliginki (see p. 22) will find them hard to use in the modern world. A mature tropical forest is diverse — many different species, hardwoods and softwoods, mixed in a tangled growth in which selectivity is at least expensive and perhaps impossible. But world markets demand only a few of the scores of different tree species which can be harvested in a tropical forest.

Neither changing the world market system nor simplifying the forest system by tree farming is practical. A better course, thinks James S. Bethel, Dean of the College of Forest Resources at the University of Washington, is to find a market for

what cannot now be marketed — to seek a demand which is "relatively indiscriminate with respect to wood properties," as he expressed it to the materials symposium at the National Academy of Sciences this spring. Two suggestions: — Use the harvested but unmarketable forest products locally for fuel — either directly or for charcoal, which may be an exportable product.

— Convert the unmarketable forest products into chemicals or fibers for which there is export demand.

The second proposal is often viewed as impractical because of the high cost of the energy needed to convert wood into fiber. But Dean Bethel suggests another look: let surplus forest products fuel the process by which other surplus products are converted into useful exports — "an interesting substitution option," says Dean Bethel. "Increase in the use of wood as a fuel would add to the potential for other wood uses because it would contribute an essentially species-indiscriminate component to the utilization system." — J.M.

HEALTH

## Hard Times and Public Health

Now that industrialized nations are facing up to the terrors of famine, pestilence, and local wars, a new trend emerges. The death rates in industrialized nations (specifically England, Wales, the U.S., and Sweden) go up when G.N.P. turns down.

G.N.P. reaches beyond economics to the realm of public health when its downturns cause social stress, says Harvey Brenner, professor in the School of Hygiene and Public Health at Johns Hopkins University. He correlated a rise in cardiovascular diseases, cirrhosis of the liver, preventable accidents, and deaths by violence with economic recessions and

depressions in a paper presented to the American Association for the Advancement of Science this winter.

Only since the 1930s has our physical health become more endangered by social and psychological stress than by the rigors of simple survival, Dr. Brenner explains. Sedentary occupations, overindulgent drinking, eating, smoking, and a diet high in animal fat all characterize the lifestyle typical since the Great Depression. Now, when money gets tight, breadwinners tend to follow suit, and fall prey to cirrhosis of the liver. Nerves tense accordingly, and those who are overweight and out of shape are the most likely victims of heart disease.

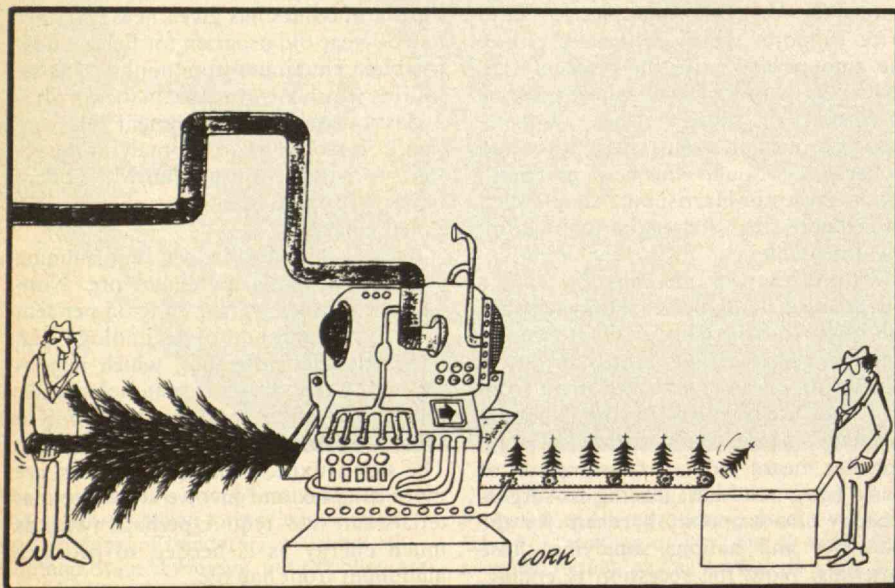
Dr. Brenner finds minorities, small children, and women the most sensitive to the nation's economic fluctuations. He thinks the connection between faltering G.N.P. and higher infant mortality reflects insufficient pre- and post-natal care and nutrition that inevitably accompany economic decline. But higher sensitivity to the economy observed in public health statistics of minorities remains puzzling, Dr. Brenner says.

Andrew Brimmer, Professor of Business Administration at Harvard, suggests a plausible explanation. Hard times widen the gap between rich and poor, he told the A.A.S. Blacks are the first to be laid off their jobs, and are hardest hit by inflation, since the majority of blacks exist on a fixed income. No surprise, then, that their physical and mental health should suffer most as a result.

In the industrialized countries surveyed, women — especially those over 60 — appear more sensitive to economic vicissitudes than men, Dr. Brenner points out. But on the whole women are less likely than men to succumb to stress-related diseases and injuries.

In fact, in 1974, women were expected to live 7.3 years longer than men, according to the U.S. Census Bureau. Men lose those years between the ages of 68.2 and 75.5 because they are far more likely to smoke, drink, accept hazardous employment, and slip into what doctors call the "coronary prone behavior pattern." A person who is work-oriented, ambitious, aggressive, competitive, and impatient is a prime target for heart disease, and is twice as likely to develop it than his or her more relaxed neighbors. Ingrid Waldron, Professor of Biology at the University of Pennsylvania, writes in the *Journal of Human Stress* (March, 1976) that this behavior pattern accounts for ten per cent of the higher mortality of men than women.

Coronary prone behavior is an acquired tempo, Dr. Waldron reports. It's adopted early in response to the social pressures of "competition for the limited number of highly rewarding jobs available" and the "large differentials in pay and intrinsic rewards" — factors which once again relate health to the state of the economy. — S.J.N.



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- M2 **Counterintuitive Behavior of Social Systems**, *Jay W. Forrester*  
Our mental models of the world in which we live are fuzzy, incomplete, and inaccurate; our responses to problems are often counterproductive. The principles of system dynamics are illustrated by the "world model" which was the basis of the famous book on *Limits to Growth*.
- M3 **New Patterns of Leadership for Tomorrow's Organizations**, *Warren G. Bennis*  
Leaders of the future will need new talents and new styles to manage their free-form, kaleidoscopic organizations
- M4 **How to Succeed in a New-Technology Enterprise**, *Edward B. Roberts*  
Studies of new-technology companies and their entrepreneurs are used to determine some general criteria for their success
- M5 **The Case for Institutional Assessment**, *Frank P. Davidson*  
Some problems which we think are technological turn out to be institutional; the assessment and design of institutions is a discipline in its own right

### Energy Self-Sufficiency: What Price Freedom?

*Technology Review* for May, 1974, was devoted to this single topic: Could the U.S. achieve complete independence from foreign energy supplies as a form of insurance against disruption, and what would be the cost? The analysis is by ten members of the Policy Study Group of the M.I.T. Energy Laboratory. Price, \$1.50

### The New Wave in the Earth Sciences

Nothing less than a revolution has shaken the earth sciences in the decade just ending — a truly new wave of understanding of the solid earth and its remarkable dynamics. Ten papers published in *Technology Review*, now collected into book form, provide a comprehensive account of "plate tectonics" and its implications for mineral exploration . . . geothermal energy . . . earthquake prediction . . . geophysical prospecting. Price, \$1.95

In their struggle to restore profitability, the railroads have powerful new technologies as their allies



Computers and television join forces to speed the classification of freight cars in the Southern Railway's \$15 million yard at Sheffield, Ala., which Southern says is the world's most completely computerized operating freight yard. The top screen shows the car on the "hump"; the lower screen projects data on the ten following

cars next to be classified. The "consist" of a train heading for the yard — including the description and destination of each car — is transmitted to the yard by computer up to eight hours before the train arrives. (Photo: Southern Railway)

# Technology and Reviving the Railroads

To many people railroads conjure images of steam locomotives and crowded passenger terminals. However, steam locomotives today are but relics, resurrected only for railroad fan outings, and passenger terminals are usually bleak, vacant places. Instead, diesel and electric locomotives pull the trains, and only freight terminals are crowded.

In the last 25 years, besides the replacement of steam-power with diesel-power, many other technical changes have come to railroading. New kinds of freight and passenger cars, computerized traffic control, piggyback and container services, and Auto-Train represent new technologies which could make a huge difference in whether the railroads can recapture their old pre-eminence.

Because today's research and development effort is far larger than in the past, the rate of technological change in the railroad industry should also accelerate. In industry, the research budget of the Association of American Railroads (A.A.R.) has grown by five times in four years, to about \$4 million in 1975.

In the federal government, several pieces of legislation have encouraged railroad technology — the High Speed Ground Transportation Act of 1965, the establishment of the Department of Transportation, including the Federal Railroad Administration of 1967; and the Railroad Safety Act of 1970.

By fiscal year 1975 the federal railroad research and development budget had grown to \$47.5 million, and in fiscal year 1976 to \$61 million. This is still small compared to budgets for aviation, space, or energy, but infinitely larger than the nonexistent budget of ten years earlier. There is every reason to believe government and industry will maintain at least their present level of railroad research.

## Railroadblocks

Each industry has its own special problems, but perhaps the railroads' problems seem special because of the many extraneous forces buffeting the industry. First of all, Interstate Commerce Commission regulation of rate structure and operating procedures indirectly affects its technology. For example, the rate structure has encouraged an increase in the size of freight cars, which in turn has increased wear and tear on the track and roadbed.

One obstacle to new technology has been the deferred maintenance of roadbeds and rolling stock forced upon railroads by their huge operating deficits. In 1975, estimates of accrued deferred physical plant maintenance

ranged up to \$10 billion.

Another bar to rapid change is the requirement that all new equipment must be compatible with existing equipment on every railroad in North America, to allow exchange of rolling stock from one railroad to another. Railroad equipment's long lifetime — 35 years for freight cars — amplifies such problems.

And finally, mortgages on railroad physical plants include "hereafter acquired" clauses. These clauses extend the lien of the lender to include all subsequent improvements. This automatically relegates any borrowing for improvements to second mortgages, which are not attractive to lenders. Thus, the railroads have been forced to finance physical plant improvements out of earnings.

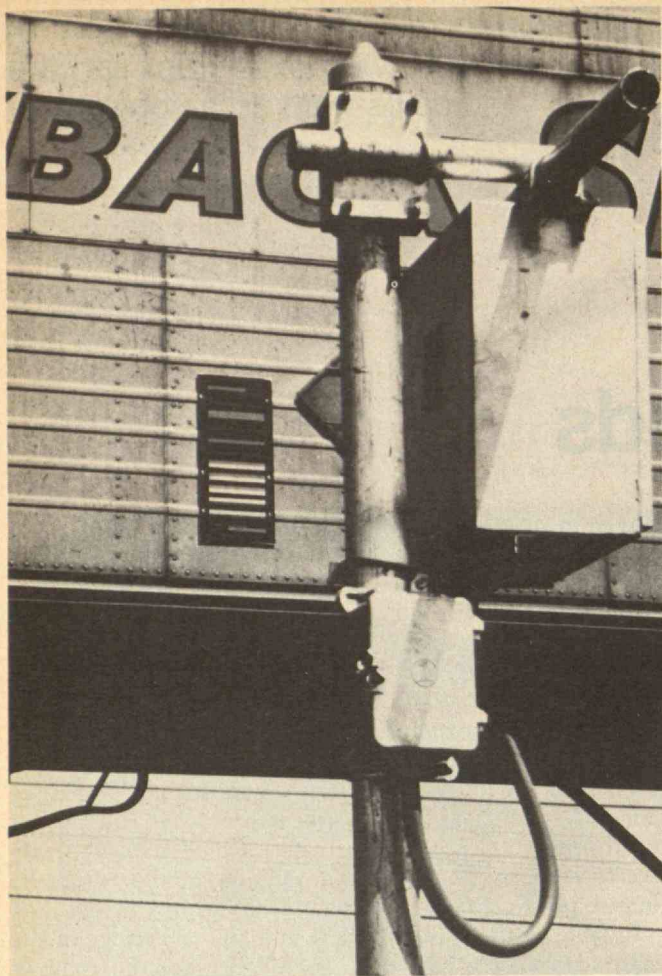
In spite of these obstacles, technological change in the railroad industry has progressed more rapidly than in some industries.

## The Evolving Engine

The basis of the railroad is of course the engine; today's locomotives are far different from earlier models, even though they may appear outwardly the same. Since the railroads completed their total conversion from steam to diesel power in the 1950s, engines have become more and more powerful — from an average of 1,600 horsepower in 1950, to about 3,600 today. The new units are cheaper per horsepower to buy, and more economical to operate. They have higher capacity motors, increased fuel capacity and better controls. Diesel electric locomotive controls have evolved with electronics technology. Solid state devices were first used in 1955 and the integrated circuit in 1973.

Radio-controlled "booster" diesel units are now interspersed in long trains to add power and give smoother braking. These booster units duplicate the power, dynamic braking, and air brake control settings of the head-end locomotive. Radio-controlled booster units have relieved excessive drawbar pull and braking on these long trains, but there are still problems: for example, the booster unit is forced to imitate the lead unit; thus, lead locomotives cannot pull while booster units are braking or vice versa. This inability to vary controls has resulted in a caterpillar-like motion of the train on undulating terrain, which sometimes breaks trains in two.

Locomotive maintenance has been revolutionized by spectrographic analysis of diesel engine lubricating oil to determine maintenance needs. No longer is large-scale maintenance scheduled at fixed intervals of time or mileage; instead samples of lubricating oil are taken regu-



Track-side electronic scanners (*left*) "read" color-coded markers on piggyback trailers to report on their location. The scanner transmits a beam of white light and receives colored light from the label attached to the trailer; the resulting data is coded in digital form and transmitted automatically by teletype to a central computer keeping track of trains and cars. The scanner can identify trailers on trains traveling at up to 100 m.p.h. (Photo: Sylvania Electric Products, Inc.) Above, "Vert-a-Pac" cars carry 30 sub-compact automobiles, engines pointing downward, at a lower cost per car than trucks can carry them. The enclosed automobiles are protected from vandalism, pilferage, and weather. (Photo: Southern Pacific Transportation Co.)

larly from each locomotive for analysis. The oil is analyzed for metal particle content; and the type of metal found tells whether piston rings, cylinder liners, engine bearings, or blowers are wearing excessively. The rate of change in the quantity of metal found is the clue to excessive wear and the need for maintenance. Lubricating oil viscosity is also checked to see if the fuel injectors are leaking and diluting the oil. These procedures have greatly lengthened the periods between major overhauls, and cut down the number of in-service failures.

### Freight with Possibilities

Although freight trains have moved more and more ton-miles of freight over the years, their share of the total market has declined. The railroads have lost significant percentages of their freight market to pipelines, trucks, barges, and air freight. To recoup these losses the railroads are trying to improve reliability and reduce travel time, and to develop intermodal freight systems combining truck and rail hauls. Clearly, the energy savings from increased rail freight would be enormous, as rail requires less than half as much fuel as trucks per ton-mile of freight.

One approach has been to improve the freight cars themselves. Until the 1940s freight cars were limited to half a dozen types which had remained essentially unchanged for generations. Then manufacturers began building larger cars. Between 1951 and 1972, the average freight car capacity climbed from 52.9 tons to 69.5 tons.

Doors have also been enlarged until some cars have all-door sides for easier loading and unloading.

Tank cars are also larger; whale-shaped cars now hold over 30,000 gallons and carry not only petroleum products, but liquid chemicals and fuels such as liquid natural gas and butane. Specialized cars have been built to haul steel, appliances, chemicals, automobiles, farm machinery, agricultural products, processed foods, and grain.

Mechanical "reefer" cars have replaced the old refrigerator cars which had to be iced. The mechanical cars carry and protect 70 tons of perishable produce at temperatures ranging from +120° to -40°F, regardless of ambient temperature.

Roller bearings have replaced sleeve bearings in the wheel units of new freight cars. These bearings, together with wayside infrared hot-box detectors to indicate overheating, have brought about a dramatic decrease in car repairs, from 5.5 repairs per million car miles in 1957 to less than 0.5 repairs per million in 1974.

Unfortunately, there is evidence that the roller bearings, which reduce lateral movement of the car's wheel and axle, impose higher lateral loads on the rails. This may be partially responsible for the recent increase in rail failures.

The new freight cars also have hydraulic draft gears to improve cushioning between cars, designed especially to protect the more sensitive electronic components, etc., being shipped today. And of course these also protect the cars themselves and allow the use of lighter cars.



How does a railroad engineer learn his romantic profession? First on a computer, then in a cab. This computer-assisted simulator asks the would-be engineer to respond to conditions projected on a screen in front of him; only after he passes this test at the Southern Railway's practice track in McDonough, Ga., does the trainee take over the controls of a real locomotive. (Photo: Southern Railway)

### New Shipping Strategies

The unit train has been an important innovation in moving large amounts of commodities such as coal or other fuels. These trains haul a single commodity continuously from one fixed point to another. Even though the cars are empty on the return trip, overall unit train services improve equipment utilization. For instance, the Denver and Rio Grande Western Railroad found that coal could be carried in unit trains from mines in Colorado and Utah to U.S. Steel's works near Provo, Utah, with only 625 cars rather than the 1000 previously used. While average freight cars may make only 20 trips a year, the cars in unit trains may make up to 150 or more trips in a year.

Perhaps the newest type of unit train is "Tank Train" developed by GATX (formerly General American Transportation Co.) to transport liquids and gases. Tank Train was tested with a three-car unit on the Alaska Railroad carrying diesel and jet fuel to military bases. The first commercial application will have trains of 20 tank cars with interconnecting hoses and special valves permitting the entire string of cars to be filled or emptied from a single connection; 463,000 gallons can be transferred in two and a half hours.

In the future, unit train service may also help answer the pressing problem of solid waste disposal. In several successful experiments, unit trains have hauled compact waste from cities to landfill areas, such as abandoned coal mines.

The Missouri Pacific has plans to haul compacted

waste by unit train from St. Louis to two power plants of the Union Electric Co. located 20 and 40 miles from St. Louis. The power plants are being built to burn an estimated 800 tons of waste per day. Operations are scheduled to begin in mid-1977.

Railroads have also given faster service by using run-through trains, which by-pass most yards and run straight through from origin to destination, pausing only for crew changes, safety inspections, and pick-up or delivery of pre-blocked cars.

Run-through trains are powered by combinations of locomotives from two or more cooperating railroads. This pooling of motive power makes possible the by-passing of interchange yards; until pooling arrangements were developed for run-through trains locomotives rarely left their own railroad.

Starting in the late 1960s freight trains have also been speeded up and given priority to improve service. Speeds of 60 m.p.h. and more were scheduled for extra service trains. One well known fast freight is the Santa Fe's "Super C" from Chicago to Los Angeles — a run-through train consisting of piggyback and container cars.

For some years trains grew longer as the industry tried to cut costs. However, a few years ago it became apparent that the time in transit of shipments had increased because of excessive time in yards to assemble and break-up the long trains. Shippers became dissatisfied and began to turn to other carriers.

Marketing studies showed that shorter, more frequent trains could provide delivery schedules more attractive to shippers. Since 1967, the trend has been to shorter trains. For example, on a Chicago-West Coast run, trains formerly left once a day and extra sections were run if necessary. Now, however, a shorter train leaves Chicago for southern California every eight hours. This greater frequency improves delivery time and spreads out the work at the terminals more evenly.

### Piggyback Trains

"Piggyback service," in which freight cars carry fully loaded shipments from other modes, goes back to the very early days of railroading when farmers' wagons were carried to market on flatcars. Modern piggyback service began in the early 1950s, and through the 1960s piggybacks, often referred to as TOFC (Trailer-on-Flatcar), grew as much as 12 to 15 per cent a year. But in the 1970s, this growth leveled off, and efforts are now underway by many roads to start the growth curve again by improving service. Faster loading and unloading equipment is being used and terminals are being consolidated to concentrate volume and eliminate interyard truck movements.

Older piggyback terminals use circus-style loading with trailers pulled up a ramp at the end of a line of flatcars and moved the length of the unoccupied cars, passing over bridge plates laid between cars, a slow, time-consuming way to load and unload. Future terminal operations will depend increasingly upon lift-off, lift-on equipment, which can transfer up to two trailers per minute.

### Shipping Autos by Train

Automobile manufacturers shipped mostly in boxcars until highway trucks were developed which could carry five or six automobiles. The cost of transporting automobiles on the highway became so much cheaper that the rail share of the market dropped below 10 per cent by



the 1950s. Then, rack railroad cars patterned after the highway trucks were introduced, and the cost of rail transport plunged below that of highway transport. Today 54 per cent of the U.S. automobile output leaves the factory by rail. To reduce vandalism, pilferage, and exposure to weather on rail auto carriers, as well as expedite loading and unloading, the Southern Pacific and General Motors developed a car to carry sub-compact automobiles loaded vertically, engines down, 30 vehicles to a rail car. The car, known as Vert-A-Pac, has side walls hinged at the bottom which serve as loading and unloading ramps.

The success of Vert-A-Pac led Southern Pacific and G.M. to develop equipment called Stac-Pac for putting standard size automobiles into containers which are carried on a flat car. The containers each carry three automobiles and are stacked two or three high.

### Unraveling Freight

While some shipments of freight can be loaded at a single point and travel directly to their destination, most freight travels on several trains between origin and destination. Each car transfer goes through a classification yard, a few inbound tracks expanding into many more parallel receiving tracks. These tracks merge again, may go over a "hump," and then fan out again into parallel tracks which then merge into the outbound tracks. In "hump" yards, freight cars are pushed over the hump and coast down to the proper track.

Trains pull into a yard and are broken up, with the cars sorted according to destination. New trains are then made up of the groups of classified cars and depart the yard for different destinations.

Many of these hump yards are being automated and their capacity thereby increased, often to about 3,000 cars daily. In automated yards, as an incoming train moves toward the hump, an automated identification scanner reads a coded number on each car's side. A computer with the train make-up already stored in its memory bank controls the operation of retarders and switches which route the cars. The computer continually updates information on the number of cars and their position on each destination track and calculates the distance each car must roll to achieve safe coupling with the standing cars. As a car rolls down the hump, radar measures its length and speed. This information is used to control the wheel retarders along the track to apply the proper amount of braking. The speed of the humping locomotive is also automatically controlled.

In spite of hump yards and automation, industry studies have revealed that classification and delays in yards are major impediments to reducing transit time and delivery on schedule. The average freight car spends less than 8 per cent of its time moving loaded in a train and over 60 per cent in classification yards, and railroads are working on a number of techniques to reduce this percentage.

### Train Talk

The railroads are also introducing new methods to communicate with and control train traffic to increase safety, and reduce delay. Anyone familiar with railroading has heard of the automated block system which displays traffic signals so that each locomotive engineer knows whether or not the track ahead is clear. Today, more effective controls and sophisticated communications systems have been introduced.

One such control method is centralized traffic control (CTC), whereby a dispatcher electrically sets switches and trackside signals. From a central control room the dispatcher coordinates the movements of dozens of trains. Sitting in front of a console he sees the trains in his sector — which may cover hundreds of miles — as lights inching along a miniaturized diagram of the tracks. The status of the train signals are indicated by green, yellow and red lights along the track and in the locomotive cab.

In 1945 CTC was in use on 6,495 miles of line; 47,060 track miles are now covered. Besides allowing greater safety, CTC permits railroads to operate moderate-traffic lines with a single track, thus saving the maintenance cost of a second track.

Newer control consoles may include color cathode ray tube displays and a computer terminal for the operator to receive reports and issue control signals.

Railroads are major users of communications, and improved railroad service is inextricably linked with better communications. Railroads use communications links to provide control of train movements, to report car locations, and to receive hot-box detector reports and data for computers, besides the usual operating and administrative messages. Railroads have contracted with telephone companies to provide system-wide internal communications, and have buried communications cables along the right-of-way for increased capacity.

Recently railroads have begun using microwave transmission, installing towers, some well over 300 feet high, along rights-of-way in many parts of North America. These towers carry hundreds of channels, giving railroads



This piggyback trailer was loaded on its flat car in the time it took to snap these pictures. Railroaders believe such speedy loading and unloading will encourage wider use of piggyback service. (Photos: Thomas Jenkins)

enough transmission capacity to even allow them to share the facilities and costs with other users.

### The Computerized Railroad

Railroads were among the first users of computers for keeping business records, but more recently computers have been used to help solve operational problems. Computer models and simulations are giving managers an entire new level of fact-finding and decision-making, and the computer has become a powerful ally of maintenance and design engineers. It determines the best way to maintain track, to figure stresses in freight car designs and to calculate the life and maintenance requirements of freight car components. And the computer is even aiding the locomotive engineer in keeping his freight train on schedule for its daily runs.

Computer systems for managing movement of today's rail freight are far more sophisticated than most people realize. For example, the A.A.R. system is called TRAIN (Telerailed Automated Information Network). It provides over 300,000 daily reports on every movement and transaction involving the car.

### Car 54 Where Are You?

Basic to all car location systems is the capability to detect and identify cars as they pass control points and enter or leave classification yards. After evaluating over 30 different techniques for identifying cars, in 1970 the A.A.R. chose an optical system. Six-inch-by-20-inch color-coded labels are attached to cars identifying the car by type, number and owner. The labels are read by optical scanners located at strategic points along the wayside. The scanners can read labels through rain, snow or fog on trains passing at up to 80 m.p.h. The scanners transmit the data to central locations where it can be used to verify train make-up and to plan for make-up of trains at the next classification yard.

There have been difficulties with label "readability," partly due to dirty and damaged labels. Because labels have been applied to some 1,400,000 freight cars most railroads are attempting to use the system and are making progress in improving readability. Efforts are underway to improve cleaning of the labels, to use colors which are easier for the scanners to detect, and to develop scanners with greater amplification.

### The Passenger Train

Of the swarm of railroads which operated passenger services in the railroad's heyday only two now operate their

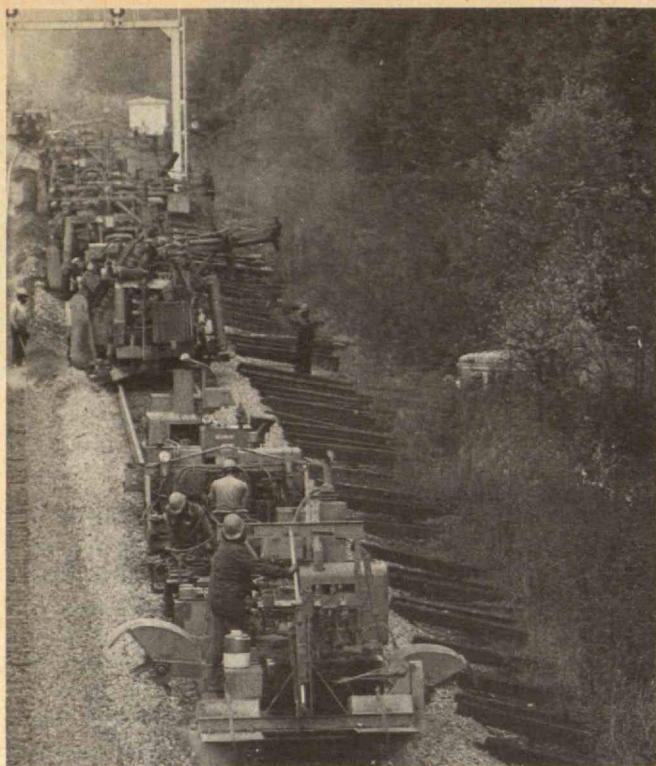
own intercity passenger service. The Southern Railway operates primarily between Washington, D.C., and New Orleans, and the Denver and Rio Grande runs service between Denver and Salt Lake City. Most intercity service is performed by the National Railroad Passenger Corporation (Amtrak) which was created by Congress in 1970 because the railroads had been losing money on passenger service for some time. Patronage had begun dropping rapidly after World War II as highways and air service were improved and expanded. Volume fell from almost 46 billion passenger-miles in 1947 to 34.6 billion in 1951. To halt the downturn, in the 1950s, railroads introduced luxury service, new equipment and large advertising campaigns. But the trend was not halted and the railroads turned to cutting costs. New equipment purchase was halted and services, from famous trains to dining cars, were eliminated one after the other, which further increased the exodus of passengers to other modes of travel. By the end of the 1960s volume was under 11 billion passenger-miles, and it became apparent another approach was needed if rail passenger service was to be preserved. The U.S. Department of Transportation proposed legislation which became the Rail Passenger Service Act of 1970, the charter for Amtrak.

Passenger service today is still a losing proposition, but there are hopeful signs. The Washington-New York-Boston (Northeast) Corridor, serviced by the modern Budd Metroliners and United Aircraft Turbo Trains, has proved that in densely populated areas good rail passenger service will be well patronized.

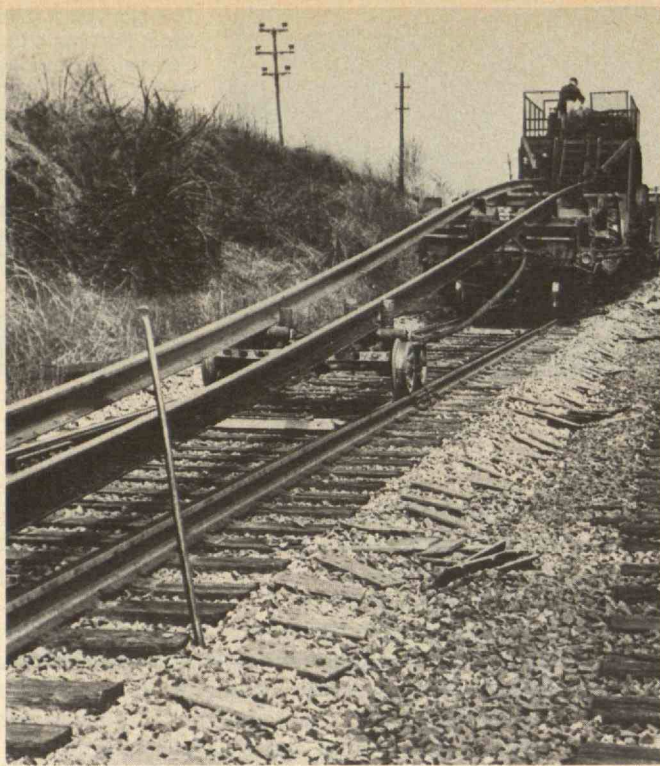
There are many problems facing Amtrak. For one thing the 1,550 cars and 420 locomotives the corporation began with were practically prehistoric. Most of the cars and locomotives had been built in the late 1940s and early 1950s. So, predictably, equipment failures have been a major obstacle to good service from the start. Amtrak began a refurbishing program in the fall of 1971, which improved car interiors, but has not reduced equipment failures satisfactorily.

New equipment has been delivered which should help ease the situation. Two leased French-built gas turbine-powered trains began running between Chicago and St. Louis on October 1, 1973. These two five-car trainsets have established a 92-per-cent reliability record and generated interest in rail passenger travel. An additional four Turboliners, manufactured by the French firm ANF-Industrie, have begun running from Chicago to St. Louis, Detroit and Milwaukee.

New electric locomotive-hauled Metroliner-type cars



The crowbar and pickax are obsolete, replaced by machines with such colorful names as electromatic (jack) tamper, switch tamper, line machine, two-plow ballast regulator, and dual remote broom — all shown in sequence in this photograph.



Quarter-mile-long lengths of welded rail roll off specially-designed cars onto the track bed; later the new rail will replace the standard, jointed rails already there. (Photos: Southern Railway)

and high-speed electric locomotives have also been purchased for the Northeast Corridor to replace the old equipment still running and bi-level coaches have been ordered for other routes.

Amtrak has also developed a nationwide computerized reservation system, in which travelers can make reservations at every Amtrak ticket office for any destination with rail passenger service.

However, one major long-term problem is the run-down stations inherited by Amtrak. Some small new stations have been built, but the large, old stations are still terribly depressing. Restaurants are gone, repairs are badly needed and the stations are generally much larger than will be needed for any possible future passenger volume. The basic hindrance to any solution of the station problem is simply that renovation of many is not economically justified.

The two-part roadbed problem is perhaps the most difficult of all for Amtrak. First, because of their bleak profit picture, many railroads have neglected maintenance-of-way until track conditions have forced lower and lower speeds for safe operation. Anyone riding a modern Amtrak train has no doubt experienced the frustration of sitting in a modern, high-speed train poking along at 20 miles per hour. The second problem is that even profitable railroads have lowered the embankment angle on curves, from that needed for high-speed passenger operations to the correct amount for slower freight trains. This has often forced Amtrak trains to either slow down or subject passengers to severe discomfort on curves. Ironically, because of track conditions, Amtrak schedules on many runs even with modern

equipment are not as good as schedules were 75 years ago. The agreed-upon purchase by Amtrak of the Northeast Corridor right-of-way will encourage maintenance of this line for passenger service and allow major stations to be rehabilitated.

Compounding Amtrak's track-imposed scheduling problems is the irritating policy of some railroads to still give priority to money-making freight trains.

So, although technology can help passenger service, before the maximum benefits can be obtained, these non-technological problems will have to be solved.

One of the brightest spots in passenger travel is the remarkable success of trains carrying automobiles together with their occupants. On routes where a 12-hour train ride could replace a two- or three-day automobile drive with motel stops, such a service seemed attractive to the Federal Rail Administration, and they tested the concept in 1967-1968. They found no technical problems and the market potential looked good. But when an appropriation was requested from Congress it was rejected with the advice, "Let industry do it."

Subsequently a D.O.T. employee, Eugene K. Garfield, left the agency and formed the Auto-Train Corp. His gamble paid off. For over four years Auto-Train has carried capacity loads between Lorton, Va., outside Washington, D.C., and Sanford, Fla., near Orlando. A second successful route between Louisville, Ky., and Sanford was added in 1974.

There have been failures with this concept. Similar service in other locations required automobiles to be loaded hours before departure, and passengers could not retrieve them until hours after arrival. In these earlier

services the automobiles were carried unprotected on open rack or flatcars. Auto-Train uses closed cars which can be loaded quickly and thus has provided a superior service.

Another promising development in passenger equipment has been the design and construction by a Canadian consortium of the LRC — Light, Rapid, Comfortable — prototype train. The coach on this train can bank itself on curves for improved passenger comfort at high speed, and a locomotive with a profile lower than normal has been extensively tested.

### The Coddled Commuter

Of course the overwhelming majority of train passengers are daily, suburb-to-city rail commuters. Rail commuter service was not taken over by Amtrak, and major rail commuter services continue in San Francisco, New York, Chicago, Boston and Philadelphia. Usually city transportation authorities contract for operation of their own equipment with railroads or subsidize losses in these metropolitan areas.

The Urban Mass Transportation Administration of the U.S. Department of Transportation has begun sponsoring development of improved commuter equipment and provides capital grants to assist the authorities in buying the new equipment.

The hybrid gas turbine-electric car is one new type of commuter car being built and tested. These cars are propelled by electric traction motors, which can derive power from either gas turbine-driven alternators or a third rail. Thus, these cars can operate on lines which are electrified in metropolitan areas and can also extend commuter service beyond the electrified territory without construction of new electrification. Propulsion is automatically switched from one energy source to the other without noticeable interruption.

The stored-energy car is a new concept for subway transit and rail commuter cars to conserve energy. The propulsion system uses an onboard flywheel which is spun up by braking energy to provide peak power to drive traction motors during acceleration. Thus energy is recovered during braking by converting the kinetic energy of the moving car into stored mechanical energy in the flywheel, rather than dissipating it as heat.

The stored-energy car is expected to demonstrate a 30-per-cent energy savings over conventional transit cars. New York Transit, if it could switch all of its 6,600 cars to stored energy, would save the equivalent of one million barrels of oil per year.

The stored-energy car would also reduce the number of electric sub-stations needed and substantially reduce subway tunnel heat by eliminating braking resistors. Also, the car would be able to move to the next station in the event of power failure, thus increasing safety.

### Farther Down the Track

This brief review should serve to illustrate that the railroads are developing quite a fund of new technology to aid their comeback. But there is still the big question of where this new technology will lead. Some predictions are possible:

The computer will be used in more and more operational tasks in railroading depending upon the management's willingness and ability to learn how to effectively use the computers' output to improve car utilization, decrease time in transit, and improve the delivery schedule

reliability. Computers are undoubtedly necessary for data processing, control, simulation, demand forecasting and optimization. This means every level of management in every phase of railroading will have to become intimately involved with computers.

The national energy conservation program may have impact on the railroad industry in several ways. Railroad transport of coal will skyrocket as power plants switch to coal from petroleum or natural gas. The volume of coal projected to be moved is so large that it may tax the ability of the industry to move it.

Because of the inherent low fuel consumption by steel wheels on steel rails, railroads may carry a larger share of the nation's freight — both fuel costs and governmental action may give railroads the edge over other modes.

The need to conserve energy may increase the pace of abandonment of lightly used branch lines. Because a locomotive hauling two or three cars uses more fuel than trucks hauling similar cargo, government may recognize energy savings as one reason to approve abandonments. Energy may also be a consideration of the federal government supporting electrification of high-density rail lines — fuel consumption for electric locomotives is about one-third that of diesel.

The economics of larger, heavier freight cars mean the trend towards bigger cars will continue and so will the acceleration of the rate at which track deteriorates.

Railroad managements' desire to give better service to shippers will mean continued changing of operating practices and continued pressure for more reliable equipment.

All these trends indicate that railroad technology should change at a quickening pace over the next few years. But nobody knows whether this faster pace will be enough to make the railroad the profitable industry it once was.

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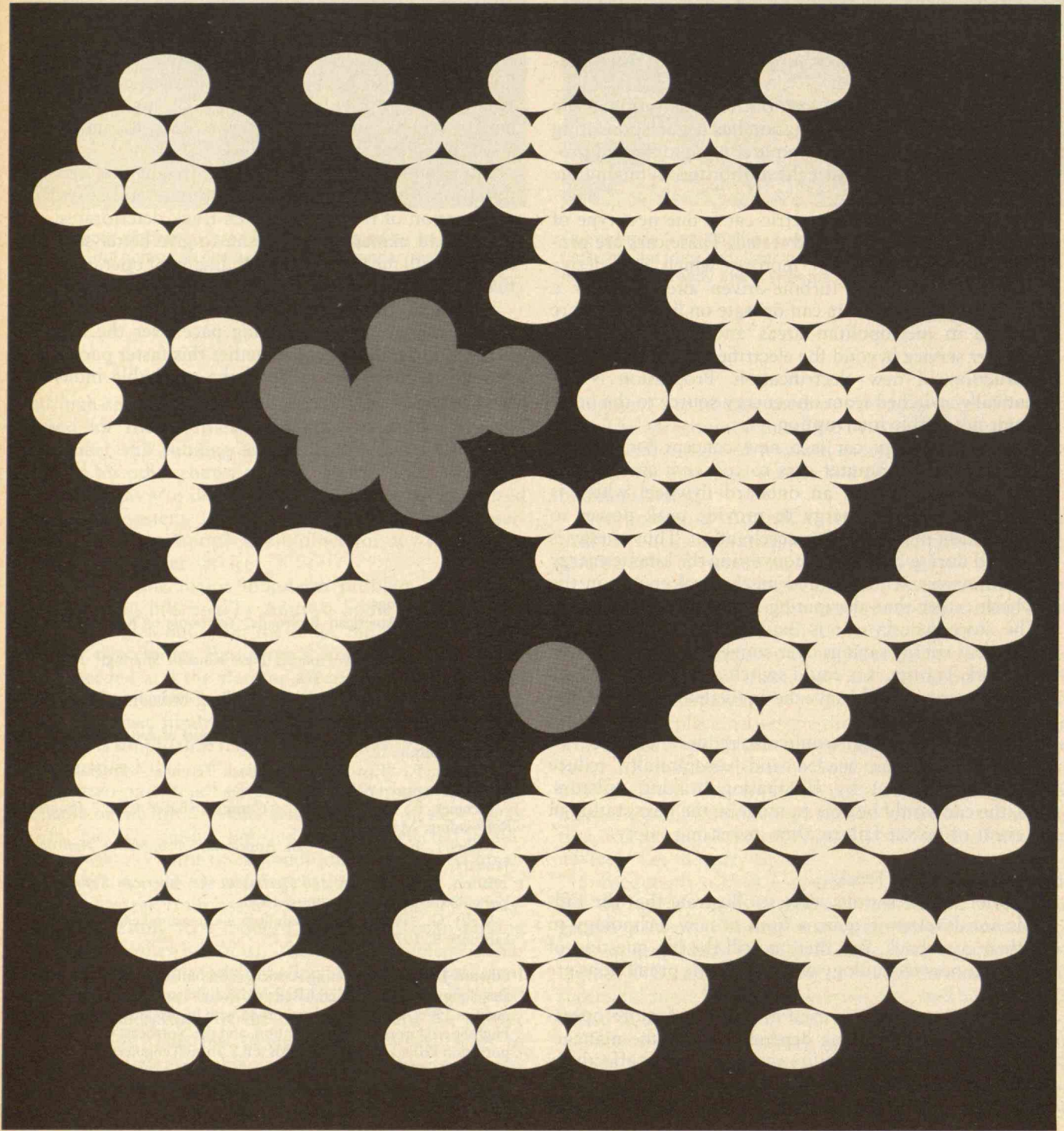
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Edward J. Ward was Acting Associate Administrator for Research and Development at the Federal Railroad Administration before his retirement in 1975, and he has also worked with its predecessor, the Office of High-Speed Ground Transportation, and the Northeast Corridor Transportation Project Office. He holds a B.S. in civil engineering from Union College, an M.S. in civil engineering from the University of Illinois, and an S.M. in industrial management from M.I.T., where he held a Sloan Fellowship in 1954-55.

Most human cancer is environmental in origin, and therefore should be preventable. Economics and politics, not science, stand in the way



# The Political and Economic Basis of Cancer

Cancer is now a killing and disabling disease of epidemic proportions. More than 53 million people in the U.S. (over a quarter of the population) will develop some form of cancer in their lifetimes, and approximately 20 per cent will die of it.

It is estimated that in 1975, 665,000 new cancer cases were diagnosed, and that there were 365,000 cancer deaths. Thus, cancer deaths in 1975 alone were approximately five times higher than the total U.S. military deaths in the Viet Nam and Korean war years combined.

Cancer spares no age, sex, or ethnic group. It is a leading cause of death at all ages, including infancy and childhood. Susceptibility to cancer has been induced even before birth, as demonstrated in post-adolescent girls whose mothers had been treated in pregnancy with the anti-abortant diethylstilbestrol.

Cancer has a major economic impact. In 1969, the estimated direct costs for hospitalization and medical care of cancer patients exceeded \$500 million. It appears that the total direct costs for any patient range between \$5,000 and over \$20,000. The direct and indirect costs of cancer, including loss of earnings during illness and during the balance of normal life expectancy, were estimated by the U.S. Department of Health, Education, and Welfare (H.E.W.) at \$15 billion for 1971.

## Increasing Incidence

Only three major causes of death have increased significantly in the recent past: cancer, homicide, and cirrhosis of the liver. Overall, deaths from most other causes are decreasing. This increase in the incidence of cancer is real, over and above that due to an increase in life expectancy, and has occurred despite advances in diagnosis and cure. Interestingly, the last major improvements in five-year cancer survival rates occurred prior to 1955, and appear to reflect the first half of the century's advances in surgery, blood transfusion, and antibiotic therapy, rather than advances in cancer chemotherapy and treatment. (Greenberg, 1975)

Cancer death rates for the U.S. are available only from 1900. Early rate estimates are crude: they are not adjusted for age, and are based on less than half of the population living in 153 cities and ten states. Overall crude cancer death rates since 1933 have increased annually by about 1 per cent until 1975, when the rate appears to have increased to approximately 2.3 per cent, according to provisional estimates.

Standardized cancer death rates, adjusted for age and based on the total U.S. population, have been available

since 1933, the year the National Center for Health Statistics was established. These more reliable data also show an overall increase in cancer death rates. Standardized cancer death rates have increased overall by approximately 11 per cent in the last four decades.

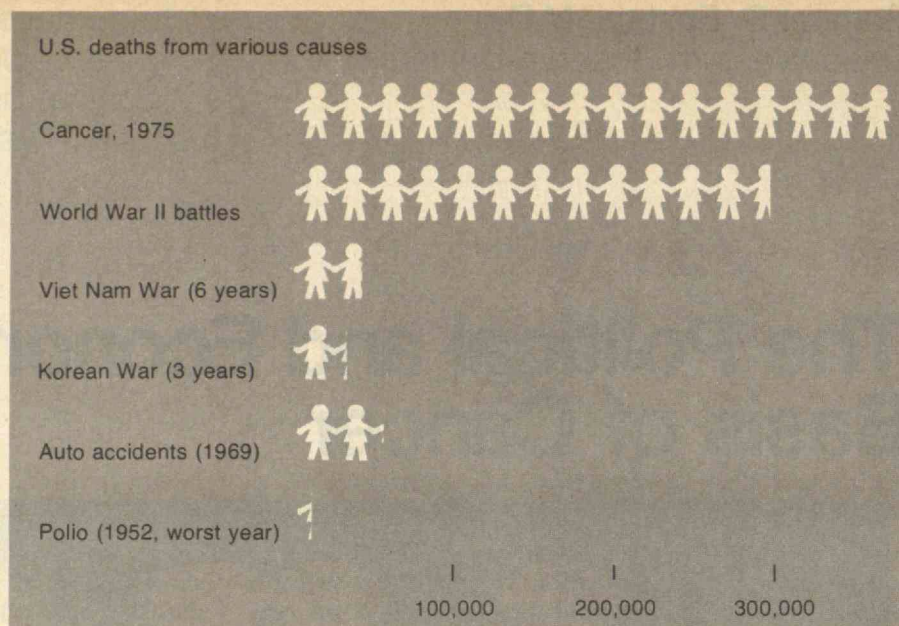
Much of the overall increase in cancer mortality since 1933 is attributable to lung cancer, and is due to smoking. Similar large increases in the incidence of cancer have been noted in other organs, particularly among blacks. Some of this increase may reflect access to improved diagnostic facilities.

At the same time, the incidence of cancer for other organs such as stomach and cervix has declined significantly (Cutler and Devesa, 1973). In fact, the decrease in the incidence of cervical cancer rates may be the source of the overall decrease in standardized cancer mortality rates for white females. On the other hand, recent evidence suggests an increasing incidence of endometrial (uterine lining) cancer, which is possibly associated with the popularity of prescribing estrogens to post-menopausal women. "Spotty" changes in cancer incidence, of which endometrial cancer is an example, and in death rates over the past few decades have, in fact, provided important epidemiological clues to environmental causes of cancer in various organs.

A recent National Cancer Institute (N.C.I.) publication, an atlas of cancer mortality rates compiled by county, shows marked geographical clustering of high cancer rates in white men and women (for various organs) in heavily industrialized areas. Such data correlate cancer rates in the general community with living near certain industries.

Apart from the importance of occupational factors in the incidence of "neighborhood" cancer in the population at large, specific occupational exposures are also an important cause of cancer deaths, particularly in males. Various estimates indicate that 5 to 15 per cent of all current cancer deaths in males are occupational in origin. These include lung cancer and pleural mesotheliomas (cancer of the chest lining) in insulation workers, construction workers, and others exposed to asbestos; bladder cancer in aniline dye and rubber industry workers, induced by such chemicals as 2-naphthylamine, benzidine, 2-aminobiphenyl, and 2-nitrobiphenyl (used in dyes and resins); lung cancer in uranium miners of Colorado, in coke oven workers, and in workers even briefly exposed to bischloromethyl ether; skin cancer in cutting and shale oil workers; nasal sinus cancer in woodworkers; cancer of the pancreas and lymphomas in organic

In 1975 alone, five times more people died of cancer than were killed in the Viet Nam and Korean conflicts combined.



chemists; and angiosarcoma of the liver in workers involved in the manufacturer and fabrication of polyvinyl chloride.

The toll of workers stricken by cancer in particular occupational exposures is overwhelming. For instance, an estimated 50 per cent of long-term asbestos-insulation workers die of cancer, and 20 per cent of all long-term asbestos workers die of lung cancer. Approximately 30 per cent of all premature deaths in uranium miners is due to lung cancer. The many other occupations that involve a high risk of cancer, include steel workers, miners and smelters, rubber workers, and workers in a wide range of petrochemical industries.

### Environmental Chemical Carcinogens

The consensus is growing that most human cancers are environmental in origin, and thus ultimately preventable. Numerous estimates by expert national and international committees suggest that 70 to 90 per cent of human cancers are environmentally induced or related; Dr. Frank Rauscher, the Director of the N.C.I., recently placed the incidence of environmental cancer at 90 per cent. The basis for such estimates largely derives from epidemiological studies in large community populations over extended periods. These reveal that the incidence of cancer varies geographically. It must be noted, however, that the role of specific environmental carcinogens so far has been implicated or identified in relatively few of the studies.

There is also general agreement now that the U.S. population and workforce has been — and is being — continuously exposed to countless known and unknown chemical carcinogens in their air, water, and food. Potent new chemical agents are being synthesized and introduced into commerce and the workplace, generally without prior, adequate testing for carcinogenicity or for other adverse public health and ecological effects.

### Detecting Carcinogens

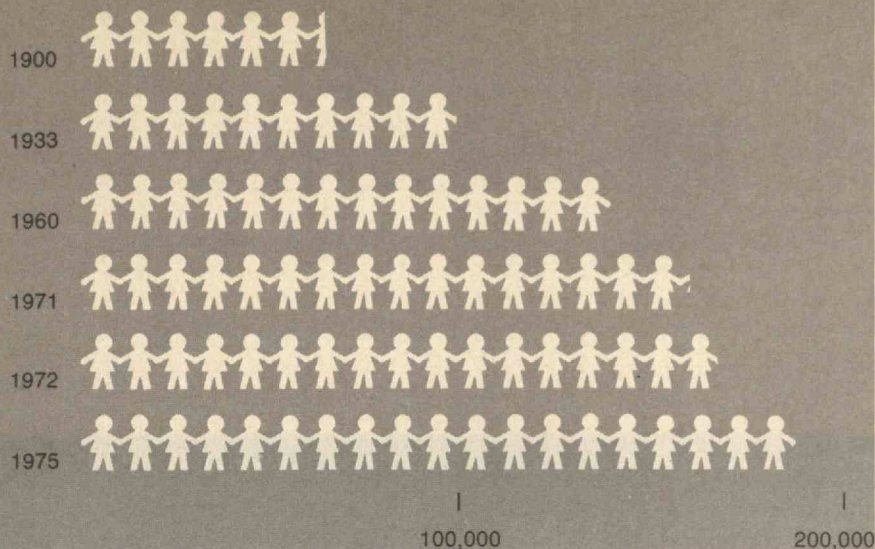
A particular chemical or mixture is determined to be carcinogenic by toxicological testing in experimental animals, or epidemiological observations in large, exposed human populations. While each approach has problems,

the results of animal testing can help pinpoint carcinogens before they are introduced to commerce and the workplace. Epidemiological studies can identify only carcinogens which have already affected the human population; they are generally based on identifying temporal or geographical clustering of specific organ cancers.

Toxicological techniques currently used on laboratory animals are relatively insensitive. Their ability to detect carcinogens — individually and in various combinations — in concentrations which reflect the low or changing patterns of actual environmental exposure is limited. In the same vein, epidemiological techniques are unlikely to detect weak carcinogens, unless there are sharp differentials in the general population's exposure, as with cigarette smoking. Even for smoking, the single largest cause of cancer deaths, several decades of investigation were required before cause and effect could be established. For widely dispersed agents, including unintentional or accidental food additives such as dieldrin and DDT, to which the population-at-large is generally and ubiquitously exposed, human experience and epidemiological observations are unlikely to provide any meaningful or immediate indication of safety or hazard.

A majority of the qualified scientific community agrees that valid and well conducted animal experiments yield carcinogenicity data with a high degree of presumptive human relevance. Indeed, every chemical known to be carcinogenic to humans, with the possible exception of tri-valent arsenic, is also carcinogenic to animals. Many chemicals now recognized as carcinogenic to humans were first identified by animal testing. These include diethylstilbestrol, bischloromethyl ether, vinyl chloride, and aflatoxins. There can be no possible justification, scientific or otherwise, for leading industrial representatives' or regulatory agency officials' continued insistence that animal data must be validated by human experience before regulatory action can be taken. Legislation has already recognized the scientific validity of data derived from animal testing: in the 1958 Delaney Amendment to the Federal Food Drug and Cosmetic Act; in such recent regulatory actions as the suspension of the major agricultural uses of dieldrin; and, still more recently, in the sus-

Cancer death rates per 100,000 population



While early estimates of cancer death rates were crude, not adjusted for age, and approximated from portions of the U.S. population, the trend nevertheless shows an upward turn.

pension of major agricultural uses of chlordane and heptachlor, whose carcinogenicity has been clearly demonstrated in animals, but not yet in humans.

In carcinogenicity tests, animals must be subjected to relatively high concentrations of the test substance. This is an attempt to reduce the gross insensitivity imposed on these tests by the relatively small size of animal groups tested, when compared to the millions of people who are presumed to be at risk. This insensitivity also applies to the numerous possible synergistic interactions between individual carcinogens, such as DDT and dieldrin, or between carcinogenic and noncarcinogenic chemicals.

Thus, safe levels of human exposure to chemical carcinogens cannot be predicted, either on the basis of animal or epidemiological data. That fact underlies the 1958 Delaney Amendment, which imposes a zero tolerance for carcinogenic food additives. The Amendment states: "... no additive shall be deemed to be safe if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animals. ..."

This position was restated by H.E.W. Secretary Casper W. Weinberger in June, 1974: "At present, the Department of Health, Education, and Welfare lacks the scientific information necessary to establish no-effect levels for carcinogenic substances in animals in general and in man in particular. In the absence of such information, we do not believe that detectable residues of carcinogenic animal drugs should be allowed in the food supply."

### Constraints to Reducing Cancer

I believe there are reasonable *a priori* grounds for associating recent cancer death rate increases with the increase of industrial chemicals in our environment, and concurrent exposure of large populations to these chemicals over the last four decades.

Such increases are likely to have occurred in other industrialized countries, although perhaps later and less dramatically than in the U.S.

Aside from some special purpose regulations of pesticides, food additives, and drugs, post-war petrochemical technology has burgeoned largely unrestricted

by national or international controls. There are no general requirements for pre-testing chemicals for carcinogenic or other adverse effects prior to manufacture or use. Consequently, many carcinogens whose effects may become manifest only now, in the next few years, or in decades, may have been used extensively. The case of vinyl chloride may be only a portent of similar disasters. Now a recognized occupational carcinogen, vinyl chloride was originally introduced into large-scale production in the 1950s. Manufacture of the substance grew at about 15 per cent per year, culminating in 1970 when about 4 billion pounds were manufactured in the U.S. Of the vinyl chloride workers identified by June, 1974, with confirmed diagnoses of hepatic angiosarcoma (a rare form of liver cancer), more than half were first exposed before 1950.

Toxic substances legislation is required to mandate requirements for toxicological testing in general, and for carcinogenicity testing in particular, of new chemical agents before their introduction to commerce and the workplace. Failure to enact such legislation, largely due to intensive lobbying by the chemical industry, is likely to result in still further increases in the incidence of cancer in the coming decades. Various adverse economic impact analyses of such legislation, procured by the chemical industry, have in general ignored the very substantial, and hitherto externalized, costs of human cancer, while exaggerating the financial cost.

Several thousand new compounds are now being introduced into commerce each year. Using appropriate systems of priorities and registration, and with the possible judicious use of short-term screening tests (McCann, *et al*, 1975), it has been estimated that approximately 500 new compounds would have to be tested each year, and that this would necessitate some four- to five-fold expansion of current facilities. This should not represent any great problem, particularly as there are abundant untapped resources in the private sector, including universities and the chemical and pharmaceutical industries. The national laboratories, such as Brookhaven, Oak Ridge, and Argonne, also represent important potential facilities.

In many cases, the federal government is meeting the bill for carcinogenicity testing of potentially profitable chemicals and products. Following an injunction to "reduce cancer rates," the N.C.I. has initiated a bioassay program, largely on industrial chemicals, and a program on "safe cigarette testing." Limited federal intramural programs are also being carried out, such as the F.D.A. tests on food additives. Clearly, national policies should be established to shift these costs from the public to the private sector, allowing industry to pay for testing in approved laboratories under contract to the N.C.I.

Even within allotted federal resources, low priority has been accorded to research on environmental carcinogens and on the prevention of human cancer. The N.C.I.'s expenditure on environmental carcinogens has been estimated at between 5 and 20 per cent of the total budget. For the 1975 budget of \$691 million, for example, direct expenditures on environmental carcinogens appear to be only 10 per cent. This low priority for environmental carcinogenesis by the N.C.I. shows up in the January, 1974, subject index of current N.C.I. grants. Only one of a total of 307 pages deals with epidemiological and population studies on cancer. Further, none of the three members of the President's Cancer Panel or of the approximately 23 members of the 1975 National Cancer Advisory Board appears to have significant professional qualifications or experience in epidemiology and preventive medicine, and only one is authoritative in chemical carcinogenesis. Industrial representation on the Board and Panel, in the absence of labor and consumer representation, also seems disproportionately strong.

N.C.I. expenditures on anti-smoking propaganda are relatively low, while research on "safe cigarettes" is well supported. The latter costs should perhaps more properly be borne by the tobacco industry, which now spends about \$250 million annually on advertising. Similar considerations apply to costs of the N.C.I. bioassay program on profitable chemicals, costs which should also be borne by the private sector. It is also significant that the U.S.D.A. spends approximately \$50 million annually on various tobacco support programs, and that its Agricultural Research Service (A.R.S.) assigns more laboratory space to research on tobacco than to research on food distribution. What's more, the A.R.S.'s concern is to produce a more marketable product, not a safer product. These federal policies are not consistent with very high national costs from the current epidemic of lung cancer, apart from bladder cancer and cardio-respiratory disease, all due to smoking.

	Whites		Blacks	
	Males	Females	Males	Females
Lung	403	238	908	435
Pancreas	61	37	200	326
Colon	48	15	100	214
Breast	—	14	—	37
Prostate	43	—	153	—
Uterus	—	-41	—	-55
Esophagus	-23	0	225	200
Stomach	-68	-77	-46	-56

A comparison of the percentage of change in the cancer death rates for selected areas between 1937 and 1969 shows the decrease in uterine, esophagal, and stomach cancer. A large proportion of the increase in lung cancer can be attributed to smoking. (Cutler and Devesa, 1973)

Both covert and overt pressures are put to bear on industry scientists to develop and interpret safety data, including data on chemical carcinogenesis, which are consistent with short-term marketing interests (Edsall, 1975). These pressures have spawned a number of myths which seem calculated to minimize the significance of the effects of human exposure to particular toxic chemicals and carcinogens. While these myths do not withstand scientific scrutiny, they have been vigorously and effectively proclaimed in public: at congressional hearings, at the proceedings of the 1973 O.S.H.A. Standards Advisory Committee on Occupational Carcinogens, at E.P.A. suspension hearings on aldrin and dieldrin, and on chlordane and heptachlor. Among these myths are the following:

— *Tumorigens are less dangerous than carcinogens.* The identity of "tumorigens," or tumor-inducing agents, as opposed to carcinogens (inducing malignant neoplasms), has been vigorously proposed, particularly for chlorinated hydrocarbon pesticides such as DDT and dieldrin. These chemicals have long been known to induce "hepatomas" (liver neoplasms) in mice. Statements to this effect have been made: for instance, one senior H.E.W. spokesperson's response to repeated congressional questioning was, "There is no evidence to my knowledge that DDT is a carcinogen." (Tepper, 1974) The invalidity of this claim has, however, been emphasized repeatedly and unambiguously by many expert commit-

	Overall	White males	White females	Non-white males	Non-white females
1935	n.d.	130.6	146.5	77.4	127.8
1940	n.d.	138.4	143.0	94.6	129.7
1945	n.d.	144.5	139.8	105.0	127.7
1950	140.5	147.6	132.4	137.6	140.8
1955	142.1	156.7	127.8	159.9	139.8
1959-61*	140.4	160.1	121.2	175.5	134.5
1964-66*	141.4	166.2	118.5	188.4	131.3
1969-71*	143.9	173.5	118.0	206.9	131.5
1973-74†	144.8	177.0	116.5	219.7	135.3

n.d. = no data    \* = 3-year average    † = 2-year average

Standardized (for 1950) cancer death rates per 100,000 people reflect a less dramatic, yet increasing toll from cancer. The decline in cancer deaths in white females can be attributed to the decrease in the incidence of cervical cancer. (Silverman and Schneiderman, 1976)

tees, who have unanimously concluded that the terms "tumorigens" and "carcinogens" have synonymous implications.

Moreover, the proposition has ceased to be relevant with the recognition of pulmonary metastases (secondary tumors in the lung), resulting from a wide range of liver neoplasms induced in mice, illustratively by "tumorigens" such as dieldrin, which also induce extrahepatic (outside the liver) neoplasms in mice and rats. Thus, there is no scientific basis for proposed regulations based on such semantics.

— *Animal carcinogens are less dangerous than human carcinogens.* This thesis proposes that valid distinctions, from a regulatory standpoint, can be drawn between chemicals causing cancer in experimental animals and those causing cancer in man. It is further proposed that less stringent regulatory standards should be promulgated for "animal" carcinogens such as ethyleneimine, dichlorobenzidine, and 4,4'-methylene(bis)-2-chloroaniline, unless and until their carcinogenic effects can be validated by human experience, based on deliberate prospective human exposure. Surprisingly, the thesis was reaffirmed by a senior E.P.A. official in January at a conference convened to review data on air pollution over certain cities. Relatively high concentrations of the dimethylnitrosamine, a highly potent carcinogen, had been identified in the air over Baltimore (where it was escaping from an FMC Corp. plant manufacturing rocket fuel), and over New York and other cities (where it is presumably formed by interaction of atmospheric nitrogen oxide pollutants and amines, from sources proba-

bly including automotive emissions, [Fine, *et al*, 1976]). The E.P.A. official, who has broad responsibilities in this area, was unwilling to define this carcinogen as a "hazardous pollutant" on the grounds that its human carcinogenicity had not yet been established.

There is, in fact, no evidence for the existence of "species-specific" carcinogens. All chemicals known to produce cancer in man, with the possible exception of tri-valent inorganic arsenic, also produce cancer in experimental animals. Recent experiences with carcinogens such as bischloromethyl ether, diethylstilbestrol, and vinyl chloride monomer amply confirm the predictive value of animal carcinogenicity data to humans.

— *Human experience has demonstrated the safety of occupational exposure to certain carcinogens.* Such claims have been made repeatedly for a number of "animal carcinogens" including dieldrin, a-naphthylamine, ethyleneimine, and dichlorobenzidine, and for "low levels" of exposure to acknowledged "human carcinogens." These claims are generally based on a lack of positive documentation of excess cancer deaths, or on the basis of undisclosed or partially accessible records covering small populations at risk, undefined turnover rates, or short periods of follow-up. Clearly, such data do not permit development of valid epidemiological inferences. Such claims fail to recognize the inherent limitations of epidemiological techniques.

— *Most chemicals are carcinogenic when tested at relatively high concentrations.* This is totally inconsistent with available information. In an N.C.I. contract to Litton Bionetics, approximately 150 industrial compounds

# Regulation of Environmental Carcinogens: Why Cost-Benefit Analysis May Be Harmful to Your Health

by Michael S. Baram

Responsibility for the regulation of environmental carcinogens is scattered throughout many government agencies today. So, as a toxic metal such as cadmium, or an herbicide, or any other carcinogenic chemical wends its way through the environment and food chain to its human receptors, it passes through the jurisdiction of many different agencies. But despite the many watchdogs, the same carcinogen may elude certain critical controls because of serious regulatory omissions or gaps in legislated authority enacted by Congress.

The federal agencies with primary regulatory responsibilities for the control of environmental carcinogens are the Environmental Protection Agency, the Nuclear Regulatory Commission, the Food and Drug Administration, and the Occupational Safety and Health Administration. However, other agencies, ranging from the Army Corps of Engineers to the Department of Transportation, also play roles in the regulation of carcinogens. Each of these agencies has statutory authority to regulate the use and emission of *some* of the substances, from *some* of the sources, in *some* of the pathways, for the purposes of protecting *some* of the population under *some* circumstances. [1-4]

Each agency has its own objectives, analytical approaches, data bases, and control criteria, but often no agency has adequate authority or motivation to control at certain critical points. Substances such as polychlorinated biphenyls (PCBs), implicated in cancer of the liver, may therefore elude coherent systematic control. To some extent, this may be due to the agencies' failure to coordinate or implement their functions properly. However, the primary problem seems to be inadequate congressional legislation, which has established agency functions in this inefficient and uncoordinated manner.

## Regulatory Patchwork

This regulatory patchwork is due mainly to uncertainty as to what constitutes cancer, the diversity of suspect substances and their pathways to their victims, the many possible but difficult-to-test synergistic factors, and the varied susceptibility of the affected population.

Environmental carcinogens fall into several classes, traceable to specific sources. The major classes of environmental carcinogens include the trace metals (beryllium, cadmium, etc.), synthetic and organic chemicals (DDT, PCBs, etc.), combustion products (aromatic hydrocarbons), other chemical products (nitrites, asbestos, etc.), and ionizing radiation from medical, industrial, and energy activities. [5]

Each presumed carcinogen has its own environmental and commercial pathway from source to human receptor. Common pathways include air, water, soil, the food chain, drug use, and the direct application of medical and other services. Some human receptors are "voluntarily" exposed as consumers and workers, some are "bystanders" who have not voluntarily subjected themselves to exposure, and some fall into both categories. The human receptors vary in their susceptibility to cancer, and those most susceptible include the

very young, the pregnant, and those who smoke cigarettes. The unborn are also extremely vulnerable to these substances, and create a relatively new and difficult class of receptors for the agencies to try to protect. [6]

The specific contribution to human cancer of each substance and each source, each pathway and causal relationship, the intervention of exogenous and synergistic factors, and the adequacy of laboratory and animal data and their extrapolation to humans are among the myriad issues besetting government regulatory agencies. As a result, the federal agencies must grapple with the serious problems of legal proof in their attempts to set standards. The same uncertainties confront the federal courts when they review agency rule-making on standards and other agency decisions. [7]

## The Analytical Pattern

At the heart of the regulatory confusion in dealing with environmental cancer is the analytical method used by the separate regulatory authorities. Many agencies employ a "balancing process," in which the costs of establishing and maintaining any levels of emission and human exposure to a carcinogen are balanced against the economic or social benefits accrued by the production and use of the substance. In some cases, agencies use a highly formalized cost-benefit analysis. (The Nuclear Regulatory Commission does this in regulating allowable amounts of ionizing radiation from the uranium fuel cycle.) In other cases, the weighing of the benefits and risks to society which would be incurred from the various levels of emissions and exposure is more informal. In either case, the net risk or cost and the net benefit is estimated, valued, and quantified before the agency determines which of several possible levels of emission and exposure it should allow, in light of available control techniques. [8]

This balancing approach leads each agency to impose a limitation or level of control on the source of an environmental carcinogen at the general point where costs or risks are equivalent to benefits. Some agencies add margins of safety or weighting factors to their analysis, either by choice or to satisfy statutory requirements.

The problems of such "balancing" approaches are obvious:

- What value should be placed on human life, illness, or suffering?

- Who should decide on such values?

- How should such values be determined?

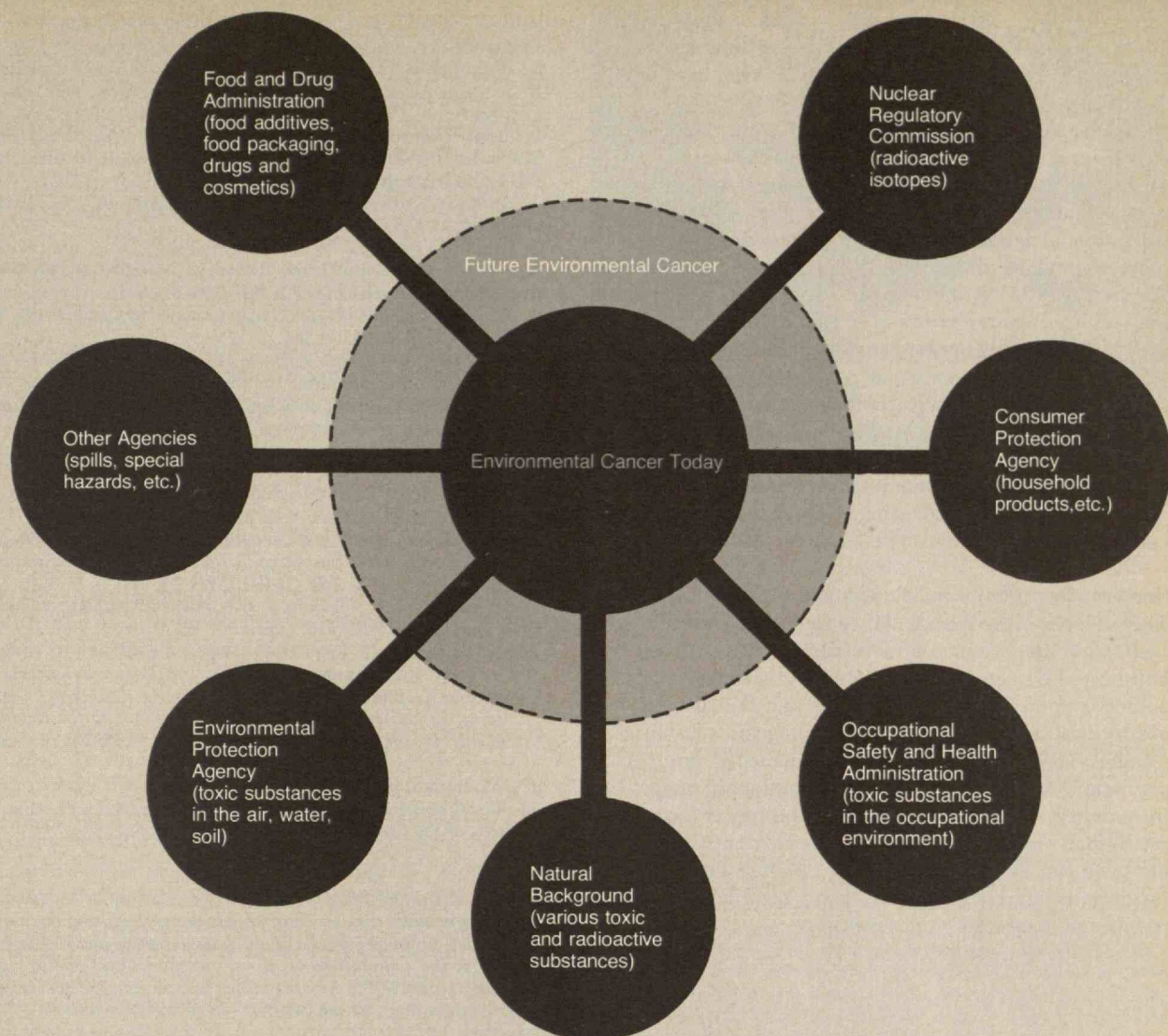
- How should we value the lives of the unborn?

- How are cases judged where benefits accrue to some but risks accrue to others? How does one judge the distributional and equity issues?

Other aspects of the balancing process also remain troublesome:

- How reliable and objective are the designated costs of new control equipment, which are largely based on information from the industry to be regulated?

- How accurate is the agency's assessment of benefits to society from the activity in question? [9]



The regulation of man-made substances which could contribute to human cancer is spread between numerous federal agencies. If each agency employs cost-benefit

analysis to determine its policies, this subdivision could have the backfire effect of increasing the total number of people exposed to environmental carcinogens.

These are significant problems for the balancing process, and at the least, new techniques are badly needed to elicit public attitudes and apply ethical safeguards to protect minorities and the unborn. For example, when the Corps of Engineers proposes to use a chemical herbicide to clear duckweed from navigational channels, and the E.P.A. approves the action (and thus approves the subsequent contamination of the water, environment, and food chain), some relatively arbitrary judgements have been made by the two agencies as to the probability of human illness or death to be sanctioned, possibly resulting from the originally beneficially intended use of the herbicide.

#### The Costs Add Up

Today's fragmented use of "balancing" by individual regulators has a pernicious, cumulative effect over many agencies' decisions. Each decision by each separate agency inevitably rationalizes an additional contribution of carcinogens

and risks to the human environment. So each decision effectively increases the total amount of environmental cancer. Such regulatory decisions occur daily. These "justifiably" allowable risks could conceivably accumulate to the point where an entire present or future population could be at substantial risk. Although each regulatory body is concerned only with its own incremental contribution to future cases of environmental cancer, each incremental contribution adds to the number of people whose lives will be affected. [10]

One may differ with this conclusion. The results of such incremental decisions may not be additive; there may be safe thresholds of exposure within which no harm occurs; the analysis possibly assumes an erroneous linear relationship between dose and response; perhaps only the same, particularly susceptible human receptors will be at risk, although their risk will be increasing. Nevertheless, some sort of cumulative effect can be expected. Over time it will be substantial.

Taken to its logical extreme, our present fragmented uses of "balancing" in regulation presents an even more absurd scenario:

Each agency justifies its own small contribution to environmental cancer on the ground that it constitutes only a minute fraction of all cancer (some agencies, such as the Nuclear Regulatory Commission, have already adopted this logic). But all agency regulations together will create an environment in which the number of cancer cases has increased. So, the catch-22: as the number of victims of environmentally induced cancer grows ever larger, the significance of each agency's contribution actually diminishes.

Therefore, an agency could conceivably justify an even greater contribution to environmental cancer in the future, and set even less effective controls on the toxic substances it is required to regulate. This scenario, while not yet realized, can be anticipated, given the fragmentation of regulatory authority and the use of balancing in the many small decisions made by the regulators. [11]

### Needed: Congressional Response

The problem of environmental cancer transcends our agencies and courts. Congress must address this problem in a holistic and systematic fashion. It must coordinate regulatory authority and establish the processes that the agencies must use to establish limitations for carcinogenic substances. If Congress continues to sanction the "balancing" approach to regulation, an overall and increasing national "budget" for the numbers of victims of environmental cancer is implicitly established. A potential victim who would not perceive his or her own case as "justifiable" cancer should therefore press for appropriate congressional action regarding the use of cost-benefit analysis by our agencies.

and pesticides were selected for test because of suspicions as to their possible carcinogenicity. These were tested at maximally tolerated doses in two strains of mice, with exposure from infancy; less than 10 per cent of these compounds were found to be carcinogenic (Innes, *et al*, 1969). Of a total of some 6,000 compounds listed in the N.C.I.'s "Survey of Compounds Which Have Been Tested For Carcinogenic Activity," approximately 1,000 were reported to be carcinogenic. By current standards, only about half of those tests could be considered valid, and a total of only 500 compounds may now be accepted as carcinogenic. I must emphasize that many of these compounds on the N.C.I. list were selected on the basis of known similarity to proven carcinogens. Many of them were chemical derivatives of known carcinogens, synthesized for basic studies on carcinogenicity. A random list of chemicals would have an even lower percentage of carcinogenic members.

— "Safe levels" of exposure to occupational carcinogens can be determined. Few if any risks are alleged to result from exposure to "low levels" of occupational carcinogens. Low levels are often determined on the basis of technical expediency, or other poorly articulated concepts. For example, the American Conference of Gov-

### Footnotes

1. Authority provided by the Federal Insecticide, Fungicide and Rodenticide Act as amended by the Federal Environmental Pesticide Control Act of 1972; the Clean Air Act of 1970; the Federal Water Pollution Control Act amendments of 1972; the Safe Drinking Water Act of 1974; and Reorganization Plan No. 3, Section 2(a) (7), 5 U.S.C.A. App. II (1970).
2. Authority provided by the Atomic Energy Act of 1954, as amended, 42 U.S.C. s. 2233 *et seq.*
3. Authority provided by the Federal Food, Drug, and Cosmetic Act, 21 U.S.C. s. 304-392; the "Delaney Clause," in the Food Additive Amendments of 1958, P.L. 85-929.
4. Authority provided by the Occupational Safety and Health Act of 1970, 29 U.S.C. s. 651 *et seq.*
5. See: *Effects of Chronic Exposure to Low-Level Pollutants in the Environment*, Subcommittee on the Environment and the Atmosphere of the Committee on Science and Technology, U.S. House of Representatives, 94th Congress, 1st session (Nov. 1975).
6. C. Moore, "Radiation and Preconception Injuries: Some Interesting Problems in Tort Law," *S. W. L. Jnl.*, v. 28, pp. 414-436 (1974).
7. H. Leventhal, "Environmental Decision-Making and the Role of the Courts," *U.Pa.L. Rev.*, v. 122, pp. 509-555 (1974).
8. "Interim Procedures and Guidelines: Health Risk and Economic Impact Assessments of Suspected Carcinogens," U.S. Environmental Protection Agency, 41 F.R. 21402 (May 25, 1975); 40 F.R. 33029 and *Final Opinion: Appendix I*, U.S. Nuclear Regulatory Commission, Docket No. RM-50-2 (April 30, 1975).
9. See "Legal and Regulatory Aspects of Using Cost-Benefit Analysis to Control Ionizing Radiation," M. Baram in *Report of the Committee on Biological Effects of Ionizing Radiation*, National Academy of Sciences (1976); and *Decision-Making for Regulating Chemicals in the Environment*, National Academy of Sciences (1975).
10. M. Baram, *Ibid.*
11. For discussion of an analogous example, see G. Hardin, "The Tragedy of the Commons," *Science*, v. 162, pp. 1243-1248 (1968).

Michael S. Baram, Professor of Civil Engineering at M.I.T., is also an attorney with the law firm of Bracken, Selig, and Padnos. He chairs the Committee on Technology Assessment, and is Vice Chairperson of the Committee on Environmental Law, of the General Practice Section of the American Bar Association. He also serves on several committees of the National Academy of Sciences.

ernment and Industrial Hygienists has assigned acceptable levels, threshold limit values (TLVs), for asbestos, bis-chloromethyl ether, and nickel carbonyl. Many independent experts have, however, attested that there is no mechanism for determining the existence of biological thresholds for chemical carcinogens, and hence that the TLV concept is inapplicable to chemical carcinogens.

The record of the National Center for Toxicological Research (N.C.T.R.), Pine Bluffs, Ark., where we might look for confirmation of carcinogenicity data, appears to reflect external pressures. The N.C.T.R. was created by presidential order on January 27, 1971, receives its financial support from E.P.A. and F.D.A., and is operated by the F.D.A. The N.C.T.R. is claimed to be a primary national source on the scientific aspects of regulation of drugs, food additives, pesticides, and other consumer products. From its inception, however, it appears clear that the F.D.A. has used the N.C.T.R. to develop data with which to invalidate the Delaney Amendment, and also to establish "safe levels" of exposure to chemical carcinogens.

Some scientific programs of the N.C.T.R., including a "mega mouse" and other large-scale experiments designed to establish "safe levels" for human exposure to

known carcinogens (such as diethylstilbestrol and benzidine), were severely criticized in an expert extramural *ad hoc* N.C.I. committee, chaired by Dr. H. L. Steward. Its report was subsequently dismissed by the director of the N.C.I. According to Dr. U. Saffiotti, then Associate Director of the N.C.I. Division of Cancer Cause and Prevention, responding to Senator John Tunney (D.-Calif.) in April, 1975, the committee's criticisms of N.C.T.R. programs remain pertinent.

### The Barriers Ahead

Certain sectors of industry have a standard response to regulatory agencies' attempts to promulgate standards limiting environmental and occupational exposure to chemical carcinogens and other toxic agents. They forecast, generally on the basis of procured reports, major economic disruption and unemployment attending compliance with the suggested regulations. These forecasts, apart from their questionable validity, do not address themselves to the externalized costs, economic and otherwise, of the carcinogenic and other toxic effects of human exposure to carcinogens.

Estimates in the summer of 1974 (by A. D. Little, under contract to the Society of Plastics Industry [S.P.I.], and by Foster D. Snell, under contract to O.S.H.A.) on the impact of proposed occupational standards for vinyl chloride, predicted costs as high as \$65 billion and losses of up to 1.6 million jobs. Such estimates are clearly gross distortions, as most PVC producers are now in compliance, in the absence of major economic disruptions (Rattner, 1975). For example, capital costs of B.F. Goodrich Co. for compliance were approximately \$34 million. This industry now is considering leasing its "clean-up" technology, and has found that the installed compliance technology actually cuts labor costs. It is of interest, however, that B.F. Goodrich has recently increased the prices of its PVC products, alleging higher production costs from compliance with regulatory standards.

Only experiences such as the ability of the PVC industry to meet occupational standards for vinyl chloride at relatively low costs can prove that safeguarding the health of consumers and workers is compatible with its primary interests. Yet the problem is clear, the evidence incontrovertible:

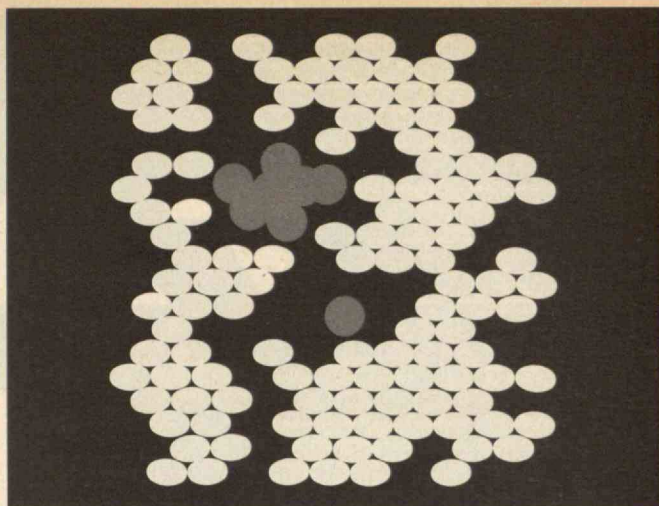
- The incidence of some human cancer is rising. Cancer is killing one in five Americans. And the economic costs of cancer are a minimum of \$15 billion a year.

- The majority of human cancers are environmental in origin, and therefore preventable.

- In addition to a number of chemical carcinogens already contaminating our air, water, food, and workplace, new carcinogens are being synthesized and introduced into commerce in increasing numbers and in a largely unregulated manner.

The solution is clear, and remains to be implemented. Its constraints appear to be mainly political and economic, rather than scientific. Toxic substances legislation must be a critical element of national policies to reduce the incidence of human cancers. Such legislation should also update current policies for regulation of environmental carcinogens by federal agencies.

Moreover, scientific research on chemical carcinogenesis conducted by industry, the N.C.I., and other federal agencies must be insulated from political and economic pressures if the principles of chemical carcinogenesis are not to be subverted further by such con-



siderations as short-term marketing interests and alleged regulatory requirements.

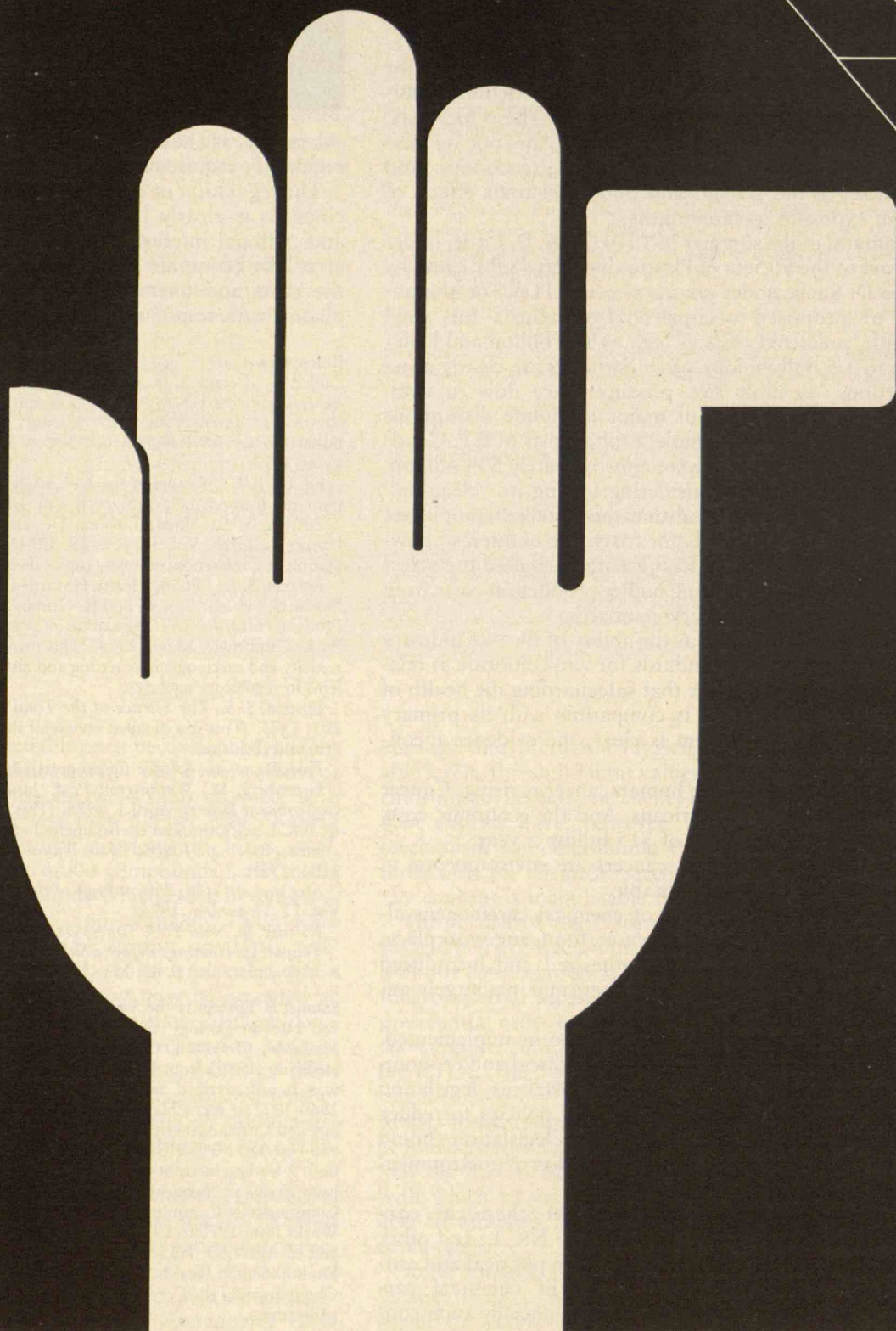
The regulation of environmental and occupational carcinogens is clearly consistent with long-term industrial and national interests. The nation's interests cannot be served by economic analyses that distort and exaggerate the costs and unemployment which may attend compliance with responsible standards.

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Samuel S. Epstein is the Swetland Professor of Environmental Health and Human Ecology at Case Western Reserve University School of Medicine, Cleveland, Ohio. He qualified in physiology (1946), and medicine (1950) from London University, England, and subsequently was Board certified in human and experimental pathology. From 1960-1972 he was Chief of the Laboratories of Environmental Toxicology and Carcinogenesis at the Children's Cancer Research Foundation and Harvard Medical School, Boston, before assuming his present position. A leading international research scientist on toxic and carcinogenic hazards due to chemical pollutants, he has been a consultant to various Congressional Committees, including the Senate Committee on Public Works from 1970 to 1974. He also consults to various Federal Agencies and to AFL/CIO. He is President of the Society for Occupational and Environmental Health, President of the Rachel Carson Trust, and Chairperson of the Commission for Advancement of Public Interest Organizations.

**TAXI**



Museum of Modern Art

# Increasing the Taxi's Role in Urban America

The goals of urban transportation are too often viewed as reducing *downtown* traffic congestion, improving suburban-to-downtown commuting, and "getting people out of cars into transit." We look too little to the ultimate purpose, which is fast, efficient door-to-door transportation. The most talked about "means" for reaching these goals invariably include the construction or extension of suburban rapid transit lines as well as subsidies for new and existing facilities, transit fare reduction (if not free transit), downtown auto bans, parking fee surcharges, and congestion tolls for autos. And rarely does this kind of rhetoric gain us more than heavy capital commitments for new or extended transit lines, new but still conventional buses or rail cars, and heavier transit deficits. Traffic congestion is not reduced; transit service seems little better — at least for most urban dwellers; and the problems of pollution, noise, energy consumption, and service for the poor and carless remain unabated.

## Population, Employment, and Transit Usage

What, then, is the urban transportation problem? To really understand the most critical aspects of that problem — or, more properly, the *set* of problems — and, in turn, the possible solutions, we need to start by looking at patterns of population, employment, and travel in and around downtowns, central cities, and suburbs as they really are and have been. The following six observations will provide a common basis of understanding — and perhaps explode some myths.

First, most people who work *downtown* — a term defined arbitrarily as the area of most intense employment — in big U.S. cities live today where they always have lived, within the central city and not in the suburbs. In New York, for example, even though its suburbs are blanketed with over 700 miles of commuter railroads (and 500 railroad stations), more than 80 per cent of the people who work downtown (i.e., south of 61st Street in Manhattan) live in one of the five city boroughs. In Chicago, whose suburbs are served by more than 400 miles of commuter railroads, roughly 75 per cent of the people who work downtown live within ten miles of the Loop. Similarly, in low-density Washington, D.C., about 80 per cent of the downtown workers live within six miles of the core. These are *not* atypical cases, and the workers they describe are the prime customers of transit systems (especially those of the rail type).

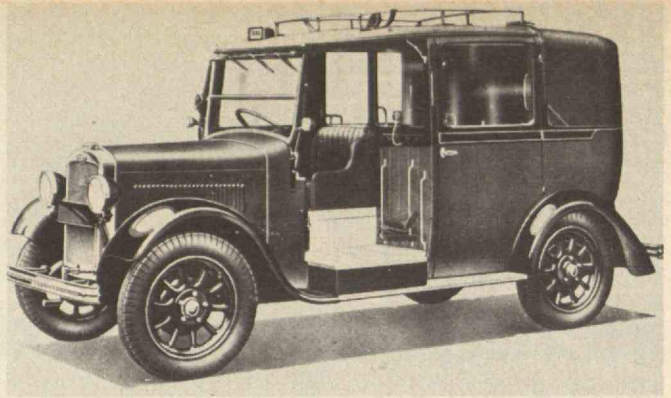
Second, the pattern is similar when the analysis is extended to workers in entire central cities — that term referring to the actual political subdivisions or jurisdictions

which are densely populated; central-city workers tend to live within the central city rather than to commute from the suburbs. In the 33 largest metropolitan areas in the U.S., about two-thirds of the central-city workers live within the city limits. In New York City, where the "central city" includes the five boroughs of Manhattan, Bronx, Brooklyn, Queens, and Richmond, the figure rises to almost 90 per cent; in Chicago and Philadelphia, it is about 75 per cent. In cities having smaller land areas the percentages are lower, but still high: over 60 per cent of San Francisco's central-city workers live within the 45-square-mile city limits; in Boston, Washington, Pittsburgh, and Cleveland (whose land areas range from 46 to 76 square miles as compared to 129 to 300 for Philadelphia, Chicago, and New York), from 44 to 50 per cent of their central-city workers live in the city itself.

Third, it is of more than passing importance to note that despite increasing average incomes of households, the number of households without automobiles available is increasing, and this is true in the case of cities which lack rapid transit systems as well as in those which possess them. In the 33 largest metropolitan areas (i.e., those having a population of 1 million or more), central-city households without automobiles available increased about 1 per cent from 1960 to 1970; the increase in those cities having rapid transit systems was even higher — about 2.5 per cent. Put in slightly different terms, about 77 per cent of the metropolitan-area households without automobiles available were located within central cities in 1970, a decline of only three percentage points since 1960. For cities having rapid transit systems, the concentrations — not unexpectedly — are even higher; in these cities, 86 per cent of the metropolitan-area households without automobiles available were located within the confines of the city limits in 1970 (a percentage which dropped only one point from 1960 to 1970). New York City, of course, is the extreme case with 94 per cent.

A fact of perhaps more significance is that the absolute number of households without automobiles available within the central-city portion of our 33 largest metropolitan areas increased just under 1 per cent between 1960 and 1970. In the six central cities having rail rapid transit systems (i.e., New York, Chicago, Philadelphia, Boston, Cleveland, and Newark), the absolute number of autoless households increased even more — about three per cent — from 1960 to 1970.

Fourth, U.S. cities now served by rail transit systems excluding San Francisco, which has a new system only recently in operation, have virtually the same central-city



populations (i.e., not including suburban residents) today as in the mid-1930s. These cities — New York, Chicago, Boston, Philadelphia, Cleveland, and Newark — had about 15 million central-city residents in 1970, 15.3 million in 1960, 15.7 million in 1950, and 14.4 million in 1930. Employment in these central cities has fallen only slightly more than population over the last two decades.

From 1960 to 1970, the (combined) central-city population of the 33 largest metropolitan areas declined only slightly more than one per cent, a figure which hardly attests to massive decentralization. (Of course, this is *not* to say that central cities and suburbs during these periods were experiencing the same growth rates or patterns. It simply reports that in absolute numbers central cities have roughly held their own despite massive suburban growth; the substantial absolute decline in transit patronage can hardly be attributed to decreases in central-city population or employment.)

Fifth, the 1970 employment statistics for the 33 largest metropolitan areas show that:

- only 14 per cent of the employees in these metropolitan areas are central-city workers who live in the suburbs (i.e., outside the city limits);
- only 10 per cent of the employees in these areas work within the central business districts;
- less than 4 per cent of the total employees in these metropolitan areas work in central business districts *and* live in the suburbs.

Sixth, from 1950 to 1960 rail transit patronage decreased from roughly 2.1 billion to about 1.7 billion passengers, and from 1960 to 1970 the total decreased somewhat less to about 1.6 billion. The reduction in rail transit ridership between 1950 and 1970 was about five times larger than the decrease in central-city population during the same period in the six cities which had rail transit systems. Overall transit ridership — to include bus and other surface transit — dropped even more during these two decades — from 13.8 billion in 1950 to 7.5 billion in 1960 and to 5.9 billion in 1970.

#### A Better Match of Need and Service

Two analyses of these facts and trends are important in evaluating past and present transit services, services which have been proposed, and other services which have been overlooked.

First, in general, city dwellers — who by far represent the bulk of transit system users — have not become noticeably less numerous; they have simply deserted the available transit systems, a phenomenon which is espe-

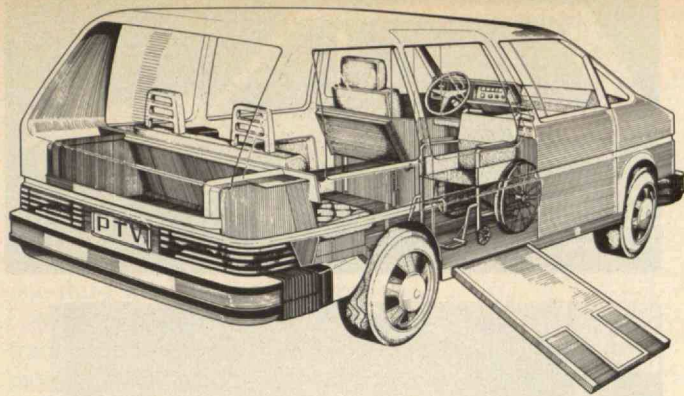
cially remarkable in view of the facts that central city residents (as a group) are the poorest people in a metropolitan area (and increasingly so, relative to suburbanites) and that the number of households without automobiles is increasing within central cities. In short, the principal market for transit has remained virtually intact, and perhaps even increased between 1950 and 1970, especially in terms of riders who may be regarded as captive because they have less freedom of choice.

Second, the suburb-to-downtown commuter — upon whom we concentrate so much attention — even today represents but a tiny fraction of the metropolitan commuter market (perhaps one person in 20, at best). Even the suburb-to-central-city commuter represents only about one-seventh of the overall metropolitan-area commuter market, a group which is declining as a proportion of the urban work travel force.

The inevitable conclusion is that the decline in transit patronage on both rail and surface transit systems in our largest metropolitan areas during the last two decades must be attributed for the most part to something other than the decentralization of city residents and jobs.

There are those who claim that these trends have developed because of total neglect of rail systems. But that is contrary to the facts: during the period from 1950 to 1970, New York and other cities with rail systems have improved the facilities, extended their coverage, and increased their subsidies. Boston has extended or vastly improved four rail transit lines since World War II. The Cleveland rail transit system has been extended twice since it was opened in 1956. Philadelphia added the Lindenwold line to its system in 1969 and extended another line. Chicago has built or extended five rail lines in the last two decades, and New York has extended or improved two transit lines in the same period. On most of these systems, both the number of revenue vehicle miles and travel speed have increased. And patronage has steadily declined on all of them, except for a brief (but still small) "boom" that stemmed from the recent fuel shortage and except for increases that occurred for a year or so following the opening of extensions or new lines.

Nor is there good reason to expect a different pattern for the new \$1.6-billion Bay Area Rapid Transit (BART) system in San Francisco or the \$4.5-billion METRO system being built for metropolitan Washington, D.C. In fact, the patronage pattern for such new systems may be even more depressing. New rail transit systems, and the post-war extensions of old systems, tend to reach farther into the suburbs and to have fewer stations per mile than did



1937 Morris-Commercial Super Six, a typical London taxicab of the 1930s (far left). The photograph comes from *The Taxi Project: Realistic Solutions for Today*, an exhibition of the Museum of Modern Art, June 18 to September 7. All illustrations on subsequent pages are courtesy of the Museum. At left, the prototype paratransit vehicle designed by AMF, Inc., Advanced Systems Laboratory, Santa Barbara, Calif. The vehicle was commissioned by the federal Urban Mass Transportation Administration as an alternative to the conventional taxicab that would meet Environmental Protection Administration emission requirements. Powered by a 30-cubic-inch, two-cylinder steam engine, it carries up to five passengers, includes a powered ramp and sliding door to accommodate wheelchairs, and runs at a maximum speed of 75 m.p.h.

the pre-war systems, which primarily served central cities and were designed to offer stations within walking distance to as many people as possible.

For example, the average distance between stations on San Francisco's BART system is about two miles, while that on Washington's METRO will be roughly 1.2 miles. By contrast, the average station spacing on the pre-1960 rail transit lines in New York and Boston was about one-half mile and that in Chicago about two-thirds of a mile. About two-thirds of BART's stations and half of METRO's stations will be located outside the central city, scattered widely throughout the suburbs. By comparison, virtually all of the pre-1960 rail transit stations in New York, Chicago, Boston, and Philadelphia were concentrated within the central city or less than a mile from it. The new systems are trying to reach a market very much like that of the commuter railroads, a low-density market of well-to-do suburbanites. It is a very small market to draw upon; and by having stations so far apart the rail transit systems usually force commuters to drive to and from the stations in second cars which in fact offer those commuters transportation competitive with the rail systems.

In summary, the solutions now being offered to the public transportation problem (such as BART and METRO), however fast (once you get on them) and pretty, are nothing more than 1970 versions of 1870 commuter railroads that tied together the suburbs and the downtowns. They lack the accessibility and central-city coverage afforded by earlier rail rapid transit, and they fail to provide easy-to-reach, door-to-door service for most would-be users — especially for people without automobiles, for people who are physically infirm, and for people who live within central cities, close to downtown.

### The Rush-Hour Rush to the Automobile

The New York region is an example of these trends. It is the largest in numbers and the highest in density of U.S. metropolitan areas, the area most suitable for extensive, high-capacity rail systems. Its rail transit system includes some 240 miles of grade-separated transit lines with about 500 passenger stations; this system handles about 80 per cent of all the subway trips made anywhere in the U.S. About four of every five New York subway riders are bound to or from Manhattan, and most of those are headed for somewhere below 61st Street. About 90 per cent of New York's subway riders are New York City residents; about 10 per cent are middle- or upper-income suburbanites. By contrast, the commuter railroads which

cover the New York suburbs handle only one-eighth as many daily trips as the city subway system; the railroads' riders are principally upper-income suburbanites who drive to and from the railroad stations.

Even in New York City, where the fact that an automobile can move at all sometimes seems a miracle, the trend of travel is clear: during the 1960s, the five-borough population of New York City rose by about six per cent. Downtown Manhattan employment increased by about seven per cent. But subway and elevated patronage fell during the same period by nearly 10 per cent, and commuter railroads lost about the same amount of business. During this period the number of people coming into downtown Manhattan from various parts of New York City fell by about four per cent, while the number of people entering the downtown area by taxicab or automobile rose 10 per cent and the number of vehicles entering downtown went up by 20 per cent.

About 85 per cent of the person trips throughout the metropolitan New York area are made by private automobile or taxicab. By contrast, only 25 per cent of the people entering downtown Manhattan daily do so by car or cab, and during rush hours that figure drops to about five per cent. But one should not be confused by the fact that transit travel to downtown Manhattan is so popular during the rush hour; the fact is that Manhattan streets reach a saturation point at rush hours, and almost everybody travels by transit or not at all. In less dense cities, the dominance of the automobile is even more prominent, a pattern which undoubtedly will continue.

### The Growing Demand for Better Service

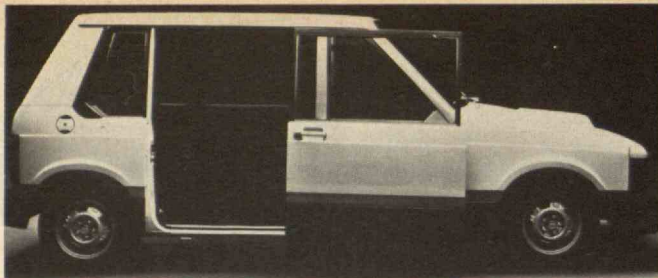
These trends of declining transit patronage, increasing vehicle flow, and declining number of people per vehicle are characteristic of modern, affluent, urban America and of large, medium, and small cities. They make clear the fact that rich and poor alike are turning away from transit, however improved, subsidized, and inexpensive, towards private automobiles and taxicabs, however expensive and however immobilized in traffic.

This trend is sometimes attributed to a "love affair" between metropolitan man and the rubber-tired monster; but it seems likely that the trend has more to do with comfort and utility than with love.

Commuters do not choose the automobile because transit fares are too high or transit service has deteriorated. Indeed, transit service has improved in many respects and is not nearly so expensive as commuting by automobile; many studies have shown that riders are rela-



**Above:** *Hors de concours*, Alfa Romeo's solution to paratransit. This four-cylinder, gasoline-powered vehicle — designed exclusively for a European market — seats five passengers and has a maximum speed of 75 m.p.h. A retractable ramp and sliding door are designed to facilitate wheelchair boarding. **Top right:** Volvo's paratransit vehicle. Its diesel engine can generate speeds of up to 85 m.p.h. It will carry four passengers with space for a wheelchair. And if the wheelbase is extended 80 cm., the vehicle can serve as an ambulance or large jitney. **Bottom right:** Volkswagen's paratransit prototype, the Transporter. Four million such vehicles are already in use worldwide. The Transporter is fueled by a hybrid-power plant — an engine using both gasoline and electricity. It carries up to five passengers with space for a wheelchair, has a retractable step, a sliding door, and travels at a maximum 43.5 m.p.h.



tively insensitive to fare increases or decreases of the sort usually invoked or proposed in most cities. Fare reductions do not significantly increase transit usage and they have little leverage for luring automobile commuters into subway cars or buses.

The figures on urban travel say this: people want good transportation service and are willing to pay for it. They know that subways and buses are cheaper than automobiles, particularly for commuting. But they also find themselves more satisfied with their lot in a car, no matter how long they spend stuck in traffic, than in walking through the rain to a subway station and then waiting to ride to a point from which they must again walk, and they obviously feel that bumper-to-bumper beats shoulder-to-shoulder.

The urban traveler wants good door-to-door service which is free from waiting, walking, transferring, and crowding and which provides comfort, privacy, and convenience. And the urban traveler has made it clear that, at the present time and for most urban trips, he will use a private automobile when he can afford it because it comes closer to providing what he wants than any other available mode of travel.

The key issue is service; that alone explains the success of the automobile. Private automobiles and taxicabs, quite simply, can provide attractive and convenient door-to-door (the key within the key) service at a price that most travelers are willing and able to pay. The preference for the automobile and against transit is anything but a man-auto love affair; it is a choice for good but expensive service in contrast to poor but cheap service.

Furthermore, the demand is increasingly for better service. The pattern is clear. A commuter moves as soon as he can from transit to a car pool (a ride to work that is

second-to-none in terms of the budget) and from a car pool to driving alone. Eventually, if he joins the ranks of the nation's most affluent commuters, he will be able to give up the driving burden while retaining the convenient, flexible, and attractive door-to-door service afforded by the private car: he will be assigned a chauffeured limousine.

### The Role of Taxicabs: Far More Than Trivial

Thus far, discussion has been devoted to the most traditional transit forms and their role in recent decades. Little has been said — directly, at least — about the taxicab and its role in urban life, present and future.

To begin, it should be recognized that taxicabs are in every sense public transit vehicles; they represent a distinct and important segment of the transit industry. Fleet taxicabs now handle almost 40 per cent more passengers than do all U.S. rapid transit systems combined, and they carry about 60 per cent as many passengers as all bus transit systems. There are no reliable figures for individually-owned cabs in operation, though one may guess that they add a significant increment — something close to one-third of the total. As a consequence, it may be estimated that cabs of all kinds provide a mass transit service which rivals, if not exceeds, that of all other transit systems. This heavy usage occurs even though taxi fares average roughly three times more per passenger-trip and about five times more per passenger-mile than those of other transit services.

Though we do not regard taxis as vital in areas having reasonably strong, publicly supported rail or bus transit facilities, statistics show their transit service to be far more than trivial, despite the fact that they operate under numerous onerous controls and regulations. For instance,

even with New York City's notoriously restrictive taxi regulations, some 1 million people use cabs daily, as compared with about 0.5 million using commuter railroads, 2.7 million using buses, and 3.8 million using rail transit. In Washington, D.C., a much lower-density city having fairly open entry for taxicabs but nonetheless still burdened by many taxi regulations and controls (which limit the taxi supply and increase the prices), about 100,000 people use cabs daily, a figure which is about one-third the bus transit patronage.

Moreover, the taxicab industry is the only public transportation service (a few private bus firms aside) that pays its own way, including both capital and operating costs, even under rigid and usually deleterious controls (to the operator and public alike) on fares, licensing, and operations. Today fleet taxicabs alone generate gross revenues almost 40 per cent higher than those of all other transit systems combined. Employment in the fleet taxi is almost as large as total employment in all other transit operations combined.

Given some reasoned tinkering with regulation, pricing, and operation, taxicabs might very well have a profound and lasting impact on transit patronage and lead to reduced automobile commuting. It is also possible to think of ways in which taxis would better serve some urban groups who are served poorly or not at all by existing transit systems.

#### Constraints on the Taxicab in Urban Transport.

Most cities now restrict the number of taxicabs in service, either by limiting the number of licenses or by granting franchises to selected fleets and limiting the size of the fleets. New York City is the extreme case, given its size and density. The city placed a limit of about 12,000 on the number of medallion cabs in 1937, a limit which is still in effect; the medallions were originally sold by the city to individual or fleet owners for \$10 apiece. Following surrender of about 2,000 medallions, the number outstanding has remained constant at about 12,000 since 1941. Chicago and Boston (as well as other cities) have similar license restrictions, while Washington, D.C., Atlanta, and Honolulu have virtually no restrictions on the number of fleets or cab licenses. In some cities, such as Los Angeles, there are franchise limitations.

Virtually all U.S. cities also regulate fare levels and the way in which cabs can function in one way or another. For example, public agencies or political groups set zone fares or meter rates, and they often set the conditions under which drivers can pick up additional fares while they still have passengers in their cabs. (During the rest of this discussion, the term "shared-cab riding" will be used to describe a taxi operation or jitney-like service which is allowed to pick up additional passengers along the way after an initial rider has started his trip.) Sometimes meter rates are based exclusively on the distance traveled, and sometimes they reflect both the distance and the elapsed time of the trip, registering at a faster rate, for example, in heavy traffic. Sometimes taxi rates vary with group riding or the amount of baggage carried.

This question of regulation is important because the few studies conducted so far show that riders are more sensitive to the availability of taxis than they are to speeds or travel times. Cities with franchising restrictions have the smallest number of cabs and those with no licensing limits have the largest number of cabs per capita; indeed, unregulated cities have more than three times as many

## Improving Taxis with Computers

What's wrong with taxis? They're unreliable, and they're expensive. Together, these two flaws prevent taxicabs from assuming a larger, systematic role in urban transportation, says Sumner Myers, Director of Urban Systems Studies for the Institute of Public Administration.

Taxis have an inherent cost advantage: the expense per vehicle-hour is low compared with that of any mass transit vehicle. But when taxis are operated as individual "for hire" vehicles dedicated to single customers, this advantage is lost. A computer-based dispatching system which helps drivers find group riders going from and to nearby origins and destinations — a "dial-a-ride" system — would capitalize on taxis' low operating cost; for example, thinks Mr. Myers, if a taxi costs \$10 an hour to operate, a "dial-a-ride" system might break even with fares of only \$1 or \$2.

A major breakthrough in taxicab reliability is just around the corner: Automatic Vehicle Monitoring (A.V.S.), in which computers keep track of the location of all vehicles in a fleet constantly and automatically. Complaints about drivers refusing service to certain destinations and disappearing from the streets when conditions are adverse (heavy snow, rush-hour traffic) will soon be manageable, and efficient "dial-a-ride" dispatching of a mobile fleet will be practicable.

Thus the future of "dial-a-ride" in American urban transportation is called G.R.I.T.S. (Group Riding Integrated Taxi Service), writes Mr. Myers in a special transportation issue of the *AIA Journal* (December, 1975). It is a sensible evolution from the taxi as we know it, the only rational way to bring citizens the advantages of flexible, dedicated transportation, says Mr. Myers. — J.M.

cabs per resident as those with restrictions.

Restrictions also inevitably increase fare levels over those that would prevail without the artificially created "virtual monopoly." A taxicab license or medallion in New York, Boston, or Chicago, for example, has in recent years cost a new owner in the range of \$6,000 to \$35,000. This cost is passed on to the passenger; it reduces the numbers of people who can afford to take cabs, and that increases the fare for those who do and invariably lowers the available supply of taxicabs.

Fare structures are important, too. Washington, D.C., for example, uses a fixed-zone fare system and until recently did not permit higher fares during rush hours, when traffic delays clearly cause the operator's expenses to increase, and revenues to fall. Before the new rush-period surcharge was added, there were from 40 to 60 per cent more cabs on the streets during off-peak hours than there were during peak periods, when they are most needed.

In some cities, notably New York and Pittsburgh, illegal taxis or jitneys now operate and legal taxis operate illegally, meeting a demand well beyond the "legalized supply." This is especially true in poorer neighborhoods and in areas without reasonable bus or subway service,

The jitney is an old idea now being given a second thought. This stretched-out Model-T ferried passengers between Daytona Beach and Deland, Fla., from 1912 to 1915.

and it is additional evidence that the supply of taxicabs is artificially reduced by licensing and fleet restrictions. The existence of highly competitive and fairly inexpensive rental car services in some parts of the country (for example, Los Angeles) may also be a consequence of the low supply and high cost of taxis.

Indeed, there is persuasive evidence that the public could and would support far more taxicabs than are now licensed to operate in most cities. Even with current restrictions and diseconomies, taxi patronage is holding its own while other transit services decline.

Statistics suggest that certain groups already are heavy users of taxi service. In Pittsburgh, studies conducted in 1963 and 1970 show that 60 per cent of residents' legal cab journeys are made by housewives, students, unemployed, retired, or incapacitated; 42 per cent of cab users are nondrivers, and 52 per cent say their immediate families do not own automobiles. Over 70 per cent of the female riders are nondrivers; for male Pittsburgh riders

about 48 per cent are nondrivers. In Boston, according to data gathered in 1968, households with annual incomes under \$4,000 contribute about a fifth of the taxi revenues; car-owning families with incomes under \$4,000 use cabs about as often as those with incomes greater than \$10,000. A study conducted in 1972 shows that 40 per cent of the households in New York's Central Brooklyn Model Cities area with annual incomes of \$4,000 or less account for 43 per cent of the cab trips generated by that area; 72 per cent of the area's cab riders come from households without autos and 85 per cent of the area's taxi trips are made in non-medallion livery vehicles.

It is my view that changes in taxi regulation, pricing, and operation would markedly improve the availability, usage, and financial viability of cabs and probably do more than any other transit improvement to lure commuters out of cars and increase total transit patronage.

There are three major reasons for these conclusions: — The taxi can offer the quality of door-to-door service which is competitive with, if not better than, the private automobile, because the passenger rides himself at once of both the burden of driving and the nuisance of hunting for a parking space.

— The larger urban travel market, that which is diffused throughout the urban region rather than focused on the downtown and other core areas, is better served by a mobile, adaptable, accessible, and smaller-capacity taxi or shared-cab service than by bus or rail transit facilities.

— The taxicab has real advantages over other modes as a transportation service for the poor, handicapped, and elderly. The poor live predominantly in areas just outside the cores of central cities, the areas increasingly neglected by the rail and other transit systems now being built, extended, or proposed; the cab suits the needs of the handicapped and elderly, who require door-to-door service and should not endure strap hanging and panic stops.

#### How to Make Taxicabs Better Public Servants

What conditions could be established to permit taxicabs to realize the larger role in urban transit which this analysis suggests they could have? Changes in present operating conditions and regulations are necessary.

One necessary condition is lifting of barriers on the number of taxicabs which may be operated in any city and on the places within metropolitan areas where certain cabs may receive passengers. These restrictions now assure high prices and frustration for taxicab customers.

Regulations covering group and shared-cab rides should be re-examined. There are obvious economies per



The two-seater royal cab, hansom style, was in use in Paris at the turn of the century.



passenger when two or more people travel together between common origin and destination, or along common routes, and rates should reflect them. Such pooling would seem to be in the public, passenger, and operator interest. There are at present no general policies on these questions. Some cities allow an extra charge per additional passenger; in others, meter fares govern the cost no matter how many passengers are in the cab. Some cities altogether forbid a driver to pick up additional passengers once a fare is in the cab; others permit the practice during rush hours or emergencies and at specified terminals. During World War II, shared-cab riding flourished in Washington, D.C., and it has had a modest recent revival there. Moreover, during World War II and for a period thereafter, Washington taxicabs were allowed to display destination or route signs in their windows, a practice which requires no exotic technology or imagination, allows people to hail cabs which suit them, and reduces "hunting" for extra riders (and the concomitant starting and stopping delays). The dropping of shared-cab restrictions, the use of destination or route signs, and adjustments of rates to provide financial incentives to sharing for both drivers and passengers, could lead to far wider taxi availability and use and to better "car-pooling-type" arrangements than most people can now make.

We should consider more carefully the type of system under which fares are set. There are precedents for fixed-zone fares and for distance-based systems (with or without a time differential), and both have their advantages.

With a zone system, gerrymandering of zone lines can be a problem, and fares never can be matched exactly to the time or distance involved in a trip. On the other hand, passengers know in advance what the charges will be and thus can better assess alternatives — walking, bus, or subway. And drivers have an incentive that works to everybody's advantage — they take the shortest and fastest routes.

Metered fares introduce variables and tempt drivers to use circuitous routes, but they may more nearly correspond to the real cost of a trip. New York City taxi meters register both the distance traveled and the time required to travel a given distance; as cab speeds fall below a specified limit, meters tick faster. This has the effect of permitting higher fares during congested periods and encouraging drivers to remain on the streets during rush hours. Common sense would suggest that taxi fares in all cities should allow a differential between peak and off-peak periods, whether a fixed-zone or a meter system is

used. The differential would encourage higher utilization of taxis, lower fares, and increased patronage and revenues.

What about subsidies for certain taxi users? The precedent for free or reduced fares for cab trips for the elderly and for school children already exists in many bus systems; such subsidies would not represent a drastic wrench in public transportation policy. If wider subsidies are considered, there is at least the justification that such subsidies would not be used — as subsidies often are — as a lever to encourage people to use services they do not want to use; they would simply encourage a trend.

#### Toward More Choice and Better Service

It is difficult to gauge the net effect of increased use of taxicabs on other transit services, on congestion, on energy consumption, and on pollution; but one can at least make some educated guesses.

The number and patronage of taxicabs on city streets



Morris and Salom Electrobat were among the first motor-powered vehicles. Over 200 of these electric cabs were plying the streets of New York by 1900.

## New Modes for Urban Travel

Since the fuel crisis of 1973, the unconventional has become the mode in transportation study. Unconventional systems which fall between conventional transit and the private automobile — taxis, jitneys, and dial-a-ride — are called "para-transit" by the Urban Mass Transportation Administration (U.M.T.A.). "The Taxi Project: Realistic Solutions for Today" exhibited by the Museum of Modern Art from June 18 to September 7 traces the history of the urban taxi, identifies its shortcomings, and presents prototype alternatives (commissioned by the U.S. Department of Transportation and the U.M.T.A.).

In the U.S., taxis earn more than all other forms of public transport put together, and carry more passengers than rapid-rail transit and half as many as bus transit. At the same time, taxis contribute — often seriously — to the pollution and congestion of the city. Fares, too, are high — an average \$1.95 per trip, plus tips. Yet an estimated 3,400 communities have no other alternative, and the taxi has to take the place of public transport. This circumstance demands that present taxi services be updated, that legal restrictions on taxis be loosened, and that vehicles be radically transformed. New kinds of taxi-sharing operations could also be introduced, possibly using larger vehicles that could complement or even serve as a city's transit system.

— **Jitneys**, already in use in Atlantic City and San Francisco, allow taxis to run on a fixed route, pick up and drop off as many passengers as space permits, and display a board to indicate the route being driven. While legal jitneys run in only a few cities, their success makes a strong case for allowing taxi companies to expand to include shared-ride operation, which can reduce traffic congestion and conserve fuel.

The formation of more jitney fleets will require changes in local regulations to enable taxis to operate as public service vehicles. Present laws do not allow taxis to display signs indicating their destination, nor do they allow taxis to pick up more than one passenger.

— **Dial-a-ride** shared taxis have been operating in the U.S. in a small way for 40 years. In the last five years, pollution and fuel shortages have made it a system worthy of public funding; over 50 systems are now operating in 22 states. Dial-a-ride's vans or buses normally seat from 10 to 20 passengers. They are controlled by a single dispatcher, to whom requests are telephoned. The dispatcher relays the subscriber's request, and the driver plans his route accordingly.

Dial-a-ride's service is the nearest equivalent to the private automobile, at about double the actual cost of a conventional taxi service. It is particularly suited to the trip requirements of low-density residential areas. The major obstacle is cost: up to a 50 per cent subsidy is often required if fares are to be competitive.

Private taxi companies might provide dial-a-ride service more cheaply, relying upon years of management experience, sound knowledge of the areas they serve, and non-union drivers who would work for lower wages on a self-employed, vehicle-lease basis. While this looks encouraging to D.O.T., dial-a-ride is also stalled by legal prohibitions which must be lifted if the system is to realize its full potential.

— The idea of the **self-drive taxi** — a small, non-polluting city car that can be hired for short-term use — has been around for many years. In Amsterdam, an experimental self-drive taxi system — Witkar, or White Car — has been

operating successfully since 1974 (see February, 1975, p. 55). It uses electrically-propelled two-seater cars picked up from one of five recharging stations. Witkar's 3,500 club members, each of whom have paid an entry fee of 50 guilders (\$16), are given an electronically-coded membership card. A member goes to the nearest station, inserts the card in the selection pole, and dials a destination. A central computer checks the member's account, confirms parking space, and issues a key. Charges are made on a time basis of around five U.S. cents per minute. Amsterdam plans to expand Witkar to 1,000 vehicles, so that no point within the city center will be more than 300 yards from one of 150 stations.

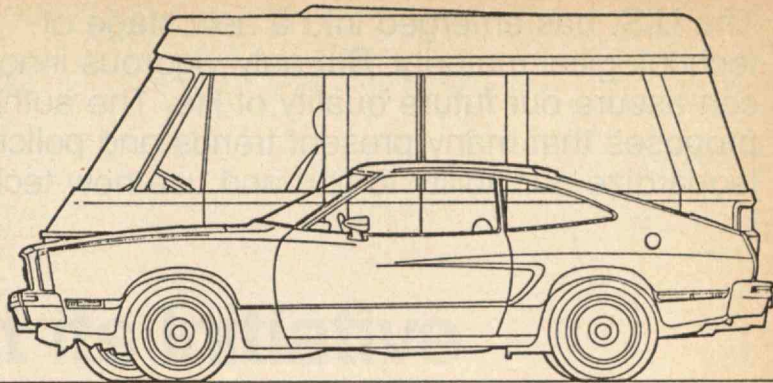
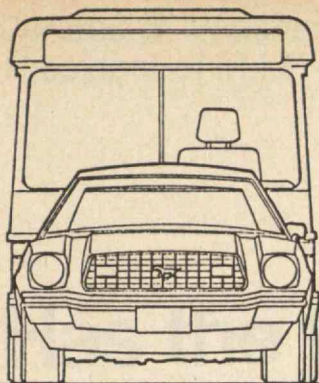
Computer simulations of self-drive taxis in the U.S. have yielded promising results, although at present market incentives are slight. But special parking facilities in city centers and more reserve limits on curbside parking could give the self-drive taxi greater appeal. The system also appears suited to compact resort areas, and to communities where a small, cheap vehicle, similar to a golf-cart, could be hired by the hour for shopping or visiting.

— **Personal rapid transit** avoids one of the most critical obstacles to taxi and dial-a-cab operation: the high cost of drivers' wages, around 45 per cent of total vehicle operation costs.

PRT runs small, electrically-propelled vehicles on an exclusive, computer-controlled right-of-way. Passengers enter a vehicle waiting at the station platform, select a destination, and are carried there with no intermediate stops. Many features of PRT are attractive: the vehicles are comfortable, stations are closely spaced with a maximum five-minute walk to or from any point within a city, and the lightweight guideways should be relatively inexpensive and visually unobtrusive. But critics point out that cost estimates for any new system are unreliable, and the number of potential users uncertain. The number of technicians required to maintain the system may outweigh the savings realized by eliminating drivers, the guideways and stations may be unacceptable in residential areas, and unmanned stations and driverless cabins may present serious social hazards.

An alternative to PRT is **group rapid transit (GRT)**, a system using larger vehicles carrying from eight to 40 passengers and requiring heavier guideways. While limited routes for GRT systems are planned in some American cities (such as Denver, where the public has already voted in favor of the system as part of a larger transportation package), GRT will meet only a few of any city's total transportation needs. The PRT system remains the most flexible. If it is ever built, it could fulfill the dreams of anyone who has experienced and enjoyed Venice: easy mobility within a totally auto-free environment.

With federal assistance for public transportation proceeding at around \$1 billion per year, it is paradoxical that under the terms of the existing Urban Mass Transportation Act, para-transit systems such as those discussed here can be eligible for grants only if they are publicly-owned. Once this restriction is abolished, private taxi operators will be encouraged to buy new kinds of vehicles and offer more innovative services. Only then will para-transit play a more serious role in urban transportation. — *Brian Richards (Condensed from his essay for The Taxi Project: Realistic Solutions for Today [N.Y.: Museum of Modern Art, 1976])*



Prototype paratransit vehicle designed by Steam Power Systems of San Diego, Calif. Also commissioned by the U.M.T.A., this van — no longer than the Ford Mustang with which it is here compared — has a 148 cubic inch, four-cylinder steam engine that

will power speeds up to 66 m.p.h. The vehicle will carry two passengers and one wheelchair passenger, or five people if squeeze-loaded. It has hydraulic doors and a powered ramp.

undoubtedly could be made to increase with major changes in government taxicab policies. The volume of commuter automobiles might be noticeably reduced, and a substantial number of private cars probably would be displaced, some being those of former car-poolers and some those of drive-alone commuters. Even assuming no net reduction either in congestion or in pollution, though some might be anticipated, the diversion from cars to cabs at least would reduce the amount of central core space that now is used for parking.

At the same time, increased taxicab patronage would to some extent come at the expense of ridership on existing transit services. But since transit services other than the taxi already suffer from an overload during peak hours, there is little if any reason to believe that public transportation as a whole — including taxicabs — would be worse off than it is now. In fact, both economies and service improvements probably can be anticipated.

Another attractive aspect of a plan to give taxicabs a larger role in urban transit is to give urban travelers a wider range of transit choices. Except for a handful of cities, travelers are limited to just two transit options — bus and private automobile. A third choice — pervasive taxi service — could be easily added, and the most compelling argument for doing so can be made by standing back from the urban area and asking what new transportation systems will best meet the most serious, expressed transportation needs and the needs of people who most need help.

However, one might argue that fewer rather than more taxis would produce better transportation service. That is, with fewer taxis, congestion would be reduced, buses and private autos would travel faster, thus producing efficiencies for bus and auto users, especially in high-density situations such as in New York City. To some extent, this argument has validity. Clearly, the remaining street vehicles would be better off with fewer taxis (or, for that matter, with fewer buses or autos). But on the other hand, fewer service options would be available to the traveling public, fewer trips would invariably be made within cities (thus reducing the economic and social benefits which stem from trips), and those with the worst transit service and with hardships (e.g., those without autos or driver's licenses, the elderly, the handicapped) would be disadvantaged. Moreover, it seems likely that businesses formerly served by taxis would incur a loss in

patrons and revenues. In sum, one can only guess about the eventual outcome — though I would expect no overall gain from a reduction in the taxi fleet.

We obviously are today devoting most of our public transportation planning to helping people who least need help. With bus and rail patronage steadily declining, with affluence and the desire for decent service increasing, and with concern for the poor, handicapped and autoless growing, unleashing the taxicab is clearly the next move to improve public transportation in our cities.

### Acknowledgement

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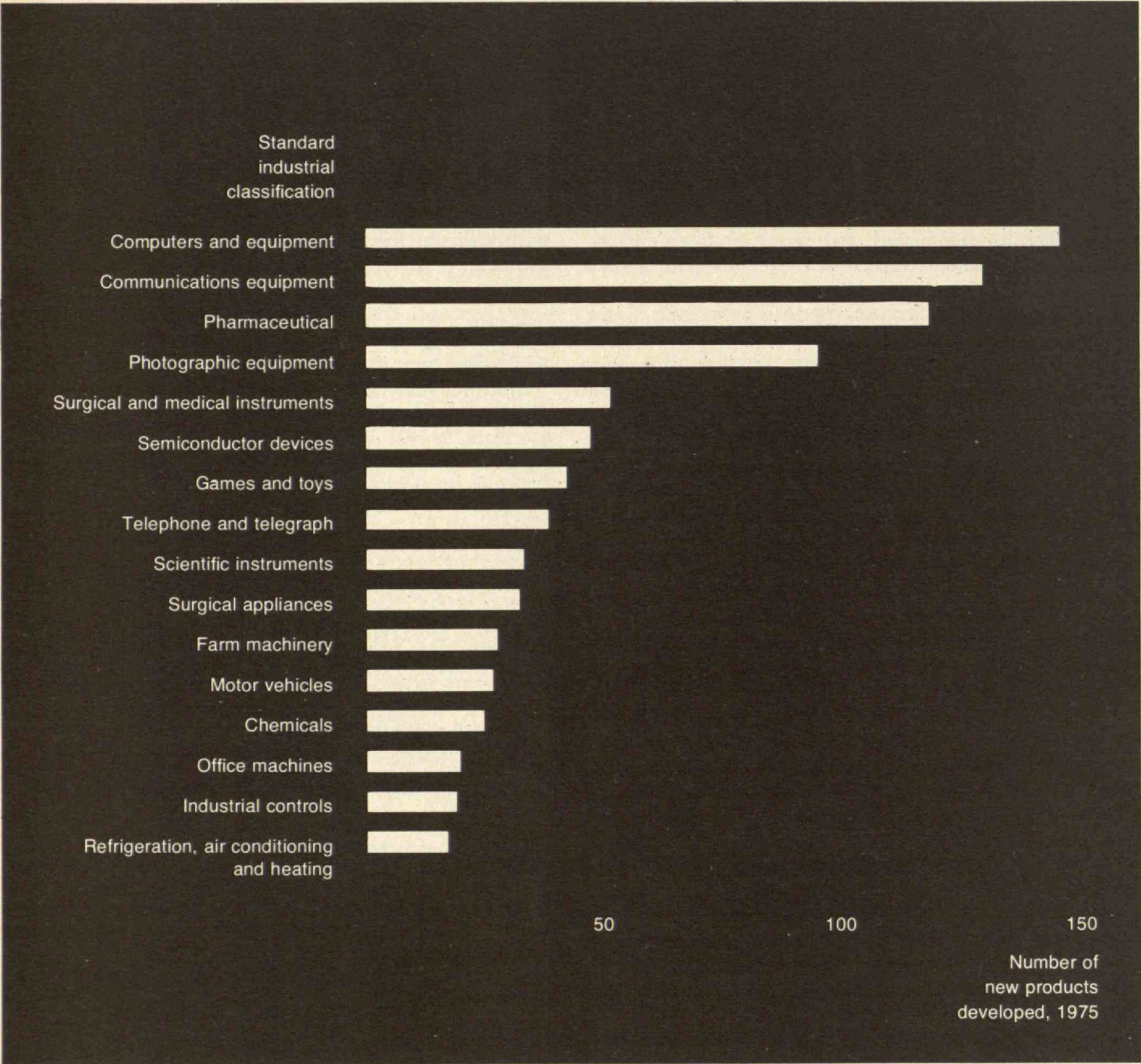
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Martin Wohl joined Carnegie-Mellon University as Professor of Transportation Systems Planning in 1972. Previously, he served as Director of Transportation Studies at the Urban Institute, as manager of the Transportation Analysis Department of Ford Motor Co., as a senior staff member of the Rand Corp., and as a faculty member of M.I.T., Harvard University, and the University of California at Berkeley. His S.B. and S.M. degrees are from M.I.T.; his D.Eng. degree is from the University of California at Berkeley. Among the 60 publications he has written or co-authored are four books, including *The Urban Transportation Problem* with John Meyer and John Kain, and *Para-transit: Neglected Options for Urban Mobility* with R. Kirby, K. Bhatt, M. Kemp, and R. McGillivray.

The U.S. has emerged into a new stage of technological maturity. But only vigorous innovation can assure our future quality of life. The author proposes that many present trends and policies jeopardize our ability to find and use new technology



Where is U.S. industrial innovation today? In computers, communications, and pharmaceuticals, says Marketing Development, a Concord (Mass.) marketing research firm. Over 3,500 "significant new products" — as determined in a survey of corporate annual reports — were developed by American companies with securities listed on the New York Stock Exchange during fiscal years ending in

1975, says M.D.; that number compares with 4,750 in the previous year. Though the data and arguments cited by Jerome B. Wiesner (opposite) are unrelated to those of Marketing Development, Dr. Wiesner's suggestion of jeopardy for U.S. technological leadership is not inconsistent with M.D.'s findings.

# Has the U.S. Lost its Initiative in Technological Innovation?

If I were forced to give a definite answer to the question which is the title of this essay, that answer would be, "No, not yet." But I see some real dangers to our nation's technological leadership, and I also have serious reservations about the context in which the question is ordinarily examined.

The state of U.S. technology is usually examined by comparing technical activities in the U.S. with those in other nations, often by comparing the size and quality of technical industries, the number of patents issued, the number of research papers published, the relative research and development budgets, and, in particular, the relative rates of growth of the various yardsticks that are being compared. Judgment on the basis of these criteria does give us cause for concern; at the least we should pause and reflect, for these measures do show unfavorable trends; for example, rates of growth of technical industries in some western European nations have exceeded by far those in the U.S. in the past two decades. But these trends also reflect, to some extent, the results of desirable and inevitable reconstruction of foreign technical capabilities and industries destroyed during World War II. It is sobering to remember that less than a decade ago a major concern, especially in Washington, was the "technological gap" between the United States and the other industrialized nations which, it was perceived, allowed the U.S. to dominate markets for technical products. Our domination was so complete and this concern so great that the governments of both the U.S. and the "lagging nations" took steps to stimulate scientific and technological activities in foreign nations.

Whatever its reality, this perception of the situation caused some countries — notably France, Germany, and Japan — to intensify their technological activities by creating national research and development plans, by increasing governmental support for basic and applied research, and by giving special incentives for the development of such high-technology products as nuclear reactors and large computers.

The fact that we in the U.S. are worried about the health of our technology suggests that those countries' efforts were highly successful. Perhaps, too, their problem was slightly exaggerated.

This foreign success was accomplished with the aid of information from American industries and universities, and it was stimulated by the U.S. government. If it turns out that U.S. efforts stimulated too much competition, the conditions of future information exchanges could perhaps be modified. But I hope that we do not attempt to

limit the flow of technological information from the U.S. (or any other country) if we do, in fact, discover the makings of a reverse technological gap.

I actually believe that the problem highlighted here goes much deeper than the matter of international trade, that it reflects problems within our own society which cannot be dealt with successfully — in terms of technological or economic competition. The real point, I believe, is that we achieved the dominant position of our science and technology by working on our own problems in a supportive social and economic setting, in an environment which encouraged scientists, educators, and industrialists to respond effectively to needs and opportunities. Until quite recently there was dynamic interplay between the private sector and government to stimulate the creative technical and economic forces which fostered the extraordinary innovative character of U.S. industry. Also, during the two decades following World War II, the activities of the Department of Defense provided extra stimulation to the U.S. technical community. If we feel that U.S. technology is now losing that inventiveness, failing to respond to existing problems and opportunities and failing to provide the basis for future economic growth, we should seek to understand what has changed in recent years.

One change certainly has not occurred: we have not run out of important problems. There is an urgent need for continued innovation not only to improve the quality of life and to continue economic development, but, even more important, to keep the system working, to retain what has been achieved, to insure that the quality of life does not deteriorate drastically because technical capabilities fail to keep up with the changing needs and resources. There are endless interesting and important challenges — new energy sources to be exploited, new materials to be created, new services to be managed. If we work on them imaginatively and effectively the United States will almost certainly remain an important leader in technological innovation.

The vital question, then, is whether the U.S. has lost the ability to innovate to meet its own societal needs; and, if so, why. Many people believe that this is the situation, or at least that problems are emerging faster than they can be dealt with. These people cite the growing complexity and scale of society's problems and the ponderousness of the human institutions that are emerging to deal with those problems.

We should note that the United States is not alone with these problems. All of the highly industrialized nations

face similar problems, though perhaps in varying mixtures. Perhaps the most vexing troubles are those which are the consequences of success — the impact of increasing industrial and agricultural productivity, the accompanying population shifts from rural to urban areas, chronic unemployment, increased life expectancy, and changing family and personal relationships. Superimposed on it all, there seems to be increased government intervention at all levels, individual and corporate, reflecting on the one hand the growing desire for security, for a “no risk” world, and on the other the need to cope with the growing interdependence of the many parts of the society.

Why is the United States less able to be creative and innovative on current problems than it was on problems of earlier, perhaps simpler, times?

I have already said that the answer does not lie in the shortage of good technical ideas; if anything, there may be too many.

I find it helpful, in thinking about this question, to distinguish between pragmatic and conceptual issues. Among the pragmatic issues are the facts of life, the many specific deterrents to innovation that we can identify and the things that might be done to improve the situation. Here I include the regulations, the economic considerations, the technical and organizational problems, and all the other specific factors that slow down the availability of new technology.

In the conceptual category are the general ideas about technology in society — the institutions and structures that support it and their evolving characteristics — that could help us to understand the sweep of events.

### Technology as Creator of Change

Let me first discuss these latter, conceptual considerations. I have reflected a good deal during the past decade on the consequences of large-scale exploitation of science and technology and the role of technology in society, and I have especially looked for those fundamental characteristics of social development that seemed to be the consequences of the use of technology. I have concluded, first of all, that — while there are real reasons for the concerns about the continuing exploitation of technology — there is no other viable option for humanity: the trade-offs are very much on the positive side. I doubt that any one of us would prefer the conditions of 100 years ago, or even those of a typical undeveloped society today, to those of contemporary life.

I have also concluded that we must accept the ever-changing aspect of a technological society. This is because of my conviction that a technologically-based society is — must be — a dynamic, learning system in a continuing state of change and evolution, requiring new technologies and new organizational forms, new relationships, and probably even new lifestyles as it evolves.

Many people find this premise troublesome. They have been hoping that the world might one day approach a steady state in which change, and especially technologically induced change, would cease. But we must accept the fact that there will not likely be a stable state in the sense that new problems will cease to arise, demanding in turn new technologies for their solution. To the extent that the present man-made world is imperfect, there are already endless opportunities for new technologies which will represent new and more effective ways to do things.

I am convinced that healthy industrial societies can only exist in a state of dynamic equilibrium that involves continuing adaptation to the changing man-made world and to a natural world that is changing as a result of people's actions.

This means that we must always face in two directions — toward nature and toward the man-made world. There is no way to avoid being creatures of nature, completely dependent upon the planet and the sun for our life-sustaining needs. At the same time we cannot turn off the synthetic world and its demands, nor run the technological clock backwards to a simpler time. So we can only strive to live in harmony with both worlds, realizing that inevitably this will involve continuing adaptation, continuing change, continuing concern for the preservation of the natural environment.

But there is no reason why change must be traumatic. Advances in science and technology should make it possible to do many things better, with less impact on the environment, with less burden and danger to the individual, less expensively, more reliably, and with more emphasis on individual well-being. Indeed, the ease, orderliness and timeliness with which new technologies are developed will determine the options of society in the decades ahead.

### The Changing Nature of Technological Needs

I believe that the social impact of new technology — rapid change and its disordering effects — is moderating. My view is that, although there is need for continuing rapid advance of science and technology to keep our society healthy and developing, the impact of such progress will in the future be much less extensive, or at least much less traumatic, than it has been in the recent past.

It is popular to say that the highly industrialized nations of the world have entered a new phase in their evolution, often described as the “post-industrial society.” I do not particularly care for that characterization of the situation; it seems to imply that the technological-industrial phase of social evolution is behind us — that industry, as it is now, is capable of supplying unlimited quantities of goods to meet all public and private needs, and that the major social problem is to use human resources and present technologies more effectively. While existing resources must certainly be used more effectively, that is not the main point. I am convinced that there remains a vital need for an effective, innovative, growing industrial sector in every society.

However, something is very different in a technologically mature society, whatever the name. During the early stages of industrialization, new technology caused major unexpected changes in the lifestyle and environment of most citizens. The electric light bulb, the automobile, and the telephone, for example, effected profound social change. But that will be less true in the future in the industrialized nations, because new technologies must increasingly be put to work to maintain the status quo or improve it modestly. There is a growing need for sophisticated replacement technology; there are countless examples to prove this point: if we develop thermonuclear fusion, it will be used to produce familiar electricity. Technology to reduce air pollution will be hidden in familiar smokestacks. We must increase food production, but most of the new products will be the same as the food we now consume. The likelihood of producing violent, traumatic discontinuities by the introduction of new

## Technological Advance and Human Growth

*Following are excerpts from an address by Howard W. Johnson, Chairman of the M.I.T. Corporation, to the Sixth Symposium of the European Management Forum in Davos, Switzerland, early this year:*

The enormous benefits of technology — and also, of course, the sometimes damaging side effects — so pervade modern society that it is almost impossible to imagine living otherwise, even so recently as a century or two ago. “No one in his senses,” said the British historian J. H. Plumb, “would choose to have been born in a previous age unless he could be certain that he would have been born into a prosperous family, that he would have enjoyed extremely good health, and that he could have accepted stoically the death of the majority of his children.”

But great as is the impact of technology on individuals, it is even greater on men as social animals — on the organizations and institutional systems under which men live. It is in this arena that managers now face a powerful challenge that to many of us seems wholly new. In one sense, in the perspective of recent history, there is nothing new about today's problems *themselves*; but there is a great deal that is new about their size, their complexity, and their implications. And they require mixed solutions that are not only technical, economic, and managerial, but political and social as well. The great failing of the solutions in the past — and a deficiency that is becoming dangerous in the present — is that they are victims of partial definition, that there is too much emphasis first on one aspect of the problem and then on another so that momentum related to a balanced definition and solution cannot be sustained. It is the interconnections of technology and human systems that make for the complications.

Yet in the mix one always returns to the central role played by technology, right up to the present, in developing the resources on which every contemporary industrial society is based. And it is clear that a continued and growing technology will be a requisite for our handling the problems of the future. It will have to be a new kind of managed technology, taking into larger account basic human and social and environmental concerns, at a new level of awareness, and with a longer time-frame in mind. The new definition will also need to take into account the international interconnections of technology and the rising aspirations of developing nations, as well as any given country's immediate and domestic present.

Such a definition will place a much larger emphasis on the research base for technology, on understanding the scientific outcomes — biological, physical, and social — of the applications of technology, and in monitoring the ongoing effects of technology. Such a definition will place more emphasis, too, on the best ways to stimulate and encourage the needed new technologies which can make such massive contributions to the solution of contemporary human and societal problems.

Those problems are manifold. They encompass the dilemmas of energy — its sources, storage, and transmission —

and, in general, of the allocation of other natural resources. They include the problems of the cities and their under-achieving systems of housing, transportation, protection, education and quality of life. And they cover the complex of problems related to medicine and health, and to food and population. Yet we *can* bring these problems closer to solution; and technologies, old and new, can lead the way.

Take food supply, for example. Technologically, there is much we can do to improve the world food situation. But we need an enlarged attack. We need particularly to focus on increased food production in the developing countries through higher yields and new methods of efficient distribution. Even in the United States, which is the Saudi Arabia of food, important areas of research vital to strengthening food protein supply are either inadequately funded or are entirely neglected.

For the developed countries, energy is almost as vital as food — and a problem of perhaps greater complexity. As with food, we must accelerate research over a broad spectrum of energy alternatives including more vigorous efforts at conservation. The research effort should include unconventional sources, such as solar energy, and continuing economic and technical feasibility studies of synthetic fuels. It should include also second- and third-generation potentialities, such as fusion, because if we do not now begin the basic research and the work on technology, we shall be caught just as short some years out as we are today.

I have said that large-scale technological advance is necessary, is possible, and is even likely, if new definitions and approaches can be made workable. There is one more ingredient, to my mind the most critical, for progress to be achieved. Understanding and managing the complex interactions of technology and society are the very heart of the matter. Let us assume that we can develop a sense of the priorities arrived at on a basis of broad understanding. Let us assume, as I believe we can, that with an appropriate research base we can develop the requisite technologies; there will still be the need for the quality of management — for human talent of greatest breadth and quality — to make the system function.

I conclude that the constraints on an effective, functioning system by the 21st century will be more human than technical. There will, of course, be changes in the natural constraints upon the system. But the most difficult constraints will relate to the need for managers in all sectors of any society who can make the largest strategic judgments in positions that carry great visibility. Of all the factors that relate to the wise and humane future development of our society, this requirement strikes me as the most complex.

Technological advance and its effective management will together not deal with all our problems. There remain the human problems like prejudice, greed, and sloth, the political problems engendered by nationalism and the decay of the spirit that man inflicts upon himself. But technological advance can provide the optimum setting for the material and social world in which human growth can be protected and encouraged, and in which it can, in fact, take place.

technologies is reduced, because our new technologies will be aimed at maintaining, rather than changing, our lives. This is a way of describing the maturity of technology.

We may also expect the impact of new technologies to be reduced because societies are learning to be on guard against undesirable side effects. In fact, we are erecting so much protection that I fear serious future discontinuities are more likely to result from failure to have new technologies available when needed than from overzealous use of new discoveries. We may fail, for example, to develop alternative energy or adequate water resources, to make safe pesticides, to develop adequate new materials or raw material sources, or to meet future food requirements; and such technological failures could have very damaging effects on the conditions of life and could lead to major political discontinuities.

What I mean is that by our emphasis on the impact of technology may be focusing on last year's problems, and we need instead to emphasize new technologies which will result in long-range strengths that go beyond our current capabilities. Such strengths will come from research and development with a long time horizon, intensified exploration, the development of new processes and new industrial facilities, and the education of a more adequate number of scientists, engineers, and managers.

In my view, this requires more understanding and much more effective management of our man-made world than it has had in the past, particularly that part which is the responsibility of the government. It also requires effective incentives for innovators, especially those in industry, even when the returns are deferred for a decade or longer.

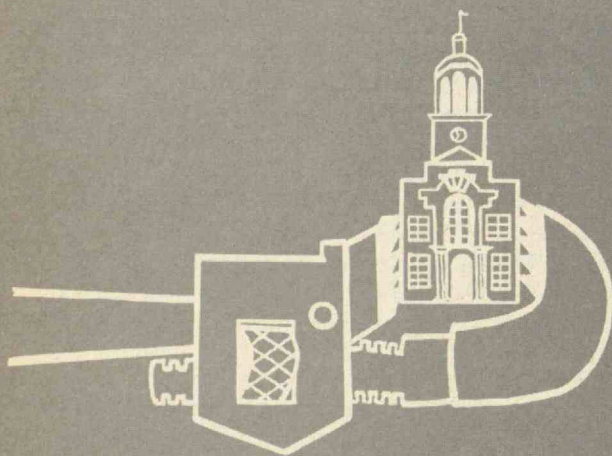
There is a "Catch-22" situation here. We obviously need prediction and planning adequate to cope with the size, time-scale, and complexity of the technological needs of a modern inter-connected society such as ours; and this implies governmental planning and management. Yet extensive government control and regulation does not appear to be an adequate solution in nations that depend upon it.

### The Learning Society

My cybernetic background has led me to regard a society as a learning machine: the social and technical evolution we are concerned about is a learning process, and our most serious national problem is learning how to create a society that can more effectively learn to solve the growing number of problems that call for collective action.

Learning occurs mostly through trial and error. A good learning system has the ability to carry out simultaneously many small experiments, and it has sensitive feedback so that the errors involved with learning are

## Special Universities in Special Jeopardy



A new economic and even intellectual climate — a "mood of austerity and national insecurity" — now poses "special dangers for the research university," Derek C. Bok, President of Harvard University, told the American Association for the Advancement of Science in Boston last winter.

Our political system and heritage are essentially egalitarian. One result is that, in Dr. Bok's words, "if there is too little money to satisfy all claims, the needs of institutions of special quality are readily dismissed as elitist and unnecessary." In austerity, too, we insist that every expenditure be justified with great care, and "such a process is not kind to the intangible values that characterize so much of the work that universities do."

And in a period of national insecurity, we tend to con-

centrate on immediate problems and crises; long-term needs are often deferred and too easily forgotten.

Thus, said Dr. Bok, there are today several trends that work against the special interests of the great research universities. There is less attention to basic research — "issues of longer-term significance where the effects are still subtle and indirect" — and more to "social problems of immediate concern." There is "a steady shift in funds away from the leading centers of research toward a broader distribution that favors a larger number of institutions." This especially has affected engineering, mathematics, and the physical sciences, said Dr. Bok, where "the decline in federal support has been much more severe for the 20 leading research institutions than for the fields as a whole"; and it has focused most sharply on expenditures for equipment and facilities, where federal funds have been cut by 50 per cent (in constant dollars) since 1968.

Three dangerous results, said Dr. Bok:

— The attention given to immediate, national problems comes at the expense of advances in fundamental knowledge and will leave us ill-prepared for future crises.

— The failure to meet universities' needs for new facilities and equipment "is already threatening the very existence of experimental science in many of our distinguished private universities," Dr. Bok declared.

— There is a special, selective threat to "the most novel, risk-taking forms of science," said Dr. Bok, "because when money is in short supply it is always tempting to concentrate support on the proven investigator tilling familiar fields." — J.M.

small. The free market satisfies these criteria reasonably when it is working, and so it has been a very effective learning machine for those things that are appropriate to the marketplace and responsive to individual initiative. Unfortunately, the free market cannot handle adequately what economists call "externalities" — pollution, education, social welfare, management of the economy, etc. — no matter how vital they are, for these require a *cooperative* rather than a *competitive* mode of behavior. Here we turn to government.

Unfortunately, all governments seem to be poor learning machines. Their feedback systems are insensitive and have very long time-constants. The feedback signals, instead of being simple profit or loss calculations, are usually value judgments, often conflicting among different groups. What are the goals of a given agency or program? Who sets them? Who judges the results? When do you change an obviously failing experiment? If this were not trouble enough, the large scale and long time constants of experiments in the public sector limit the number of experiments that can be carried out in a given period. This makes the learning process very slow. Finally, all of these factors taken together allow (perhaps even require) the errors to become very large before corrective action is taken.

These are even tougher problems, I believe, for nations that have extensive state ownership of industry than they are for the capitalist countries. In the United States we are also handicapped by the fact that the time span for consistent action is very short, essentially determined by the time until the next election and consequently hardly ever as long as four years; while many of the tasks, such as a major research or development effort or the creation of new energy or transportation systems, or the rebuilding of a city, require ten or 20 or even 30 years to carry out.

### Industrial Initiatives in Jeopardy

With these generalizations, I turn now to what I called the pragmatic reasons for the slow-down in the pace and quality of innovation and productivity increases in American industry. I believe that these developments generally fit into a consistent pattern.

The shift toward what I earlier called replacement technology has had a major effect on the rate at which innovation occurs today. New generations of processes and devices — new energy sources, new transportation systems, new pollution controls — are usually far more complex and costly than those they replace. Typically they take much longer to plan, develop, and construct. As these new processes and devices become increasingly complex, their financing will be increasingly difficult for private industry because of the very large capital investments involved or the long periods of time required for development. Together, these characteristics tend to make most such projects poor candidates for normal venture financing. Perhaps consortiums assisted by federal funds will be needed.

For many years there has been inadequate capital for new plant construction, or at least insufficient incentives for capital investment, with the result that in some important industries — steelmaking, shipbuilding, and railroad transport, for example — technology which is already available has not been fully exploited. Under these conditions there is little incentive to invest in still more advanced technology. We know that smooth-riding 200- or 300-mile-per-hour (or even faster) trains are possible,

but who will pay for them and who put them to work?

The rate of saving in the U.S. which could contribute to capital formation is approximately half of that in the nations with which we are compared in terms of our innovative well-being.

U.S. government policies frequently do not encourage industrial initiative to take advantage of new technology arising out of research and development for which the government itself has been responsible. Government patent policies, which seek to help industry use the fruits of government-sponsored research and development broadly available, actually provide insufficient protection for an industry using a particular process. Thus these policies inhibit private investment in the exploitation of new technology, particularly in industries that do not require sophisticated manufacturing know-how. Companies frequently cannot afford to invest the funds required to develop and market an unprotected product.

In some areas, elements of government dominate market decisions so completely that business cannot judge the outcome of its investment and sometimes cannot succeed no matter how outstanding its performance. This is becoming the case in the fields of energy, pharmaceuticals, and agricultural chemicals, where governmental agencies are attempting to deal with potential health hazards. We must obviously have strong regulatory activities to protect the public, including flexibility to change standards as new information becomes available; but we must understand that one consequence is a considerable slowing down of the innovative process. The increased costs, delays, and uncertainties introduced by present procedures may make private investment in research and development in many fields increasingly unattractive for all but the very largest companies. Perhaps the government should find a way to share with private enterprise the costs of proving the safety of desirable new products such as drugs that have an important societal consequence.

### The Government as Research Sponsor

The withdrawal of the Department of Defense from the support of basic research as a result of the Mansfield Amendment has damaged both basic and applied research activities in our country. The Defense Department was a very effective sponsor of research. Its program managers were in a position to relate their efforts to real needs. They were permitted to focus their programs in a limited number of locations, so that the projects they sponsored were adequately supported. Because the Department had a long-term interest in high technology in many fields — including electronics, aeronautics and astronautics, naval architecture communications, materials, and fuels — its program managers had adequate perspective to judge the quality and appropriateness of applied research activities. They were able to respond quickly, and they understood the value of teams of scientists working together on related problems. Research directors in the Department of Defense had a degree of venturesomeness, sadly missing today, which was extremely valuable to the health and progress of U.S. science and technology. Equally valuable was the multiplicity of support available to U.S. science that resulted from having so many agencies — the Office of Naval Research, the Air Force Office of Scientific Research, and the Army Research Office as well as the National Science Foundation and the Atomic Energy Commission — making independent judgements in a given field.

The federal government in general has a mixed record as a sponsor of applied research and development. Agencies which have been major consumers of high-technology products have done quite well as sponsors of applied research; the Department of Defense, Atomic Energy Commission, and National Aeronautics and Space Administration are good examples of this. However, federal initiatives have not been as effective in applied research in cases where the sponsoring agency is not a consumer. Such programs have not generated a significant increase in new methods or products. I believe this is because we do not understand the innovative process; we tend to manage applied research and development

## The Federal Presence in Research and Development

"The spirit of technological innovating and risk-taking," traditional to America, is in jeopardy, says Richard S. Morse, President of the M.I.T. Development Foundation, Inc. As a result, he says, it is "increasingly more difficult to depend upon the use of science and technology to solve our national problems."

As an expert by experience as well as training in the management of innovation, Mr. Morse — he is also Senior Lecturer in the M.I.T. Sloan School of Management — was called to testify this spring before a House of Representatives Subcommittee on Domestic and International Scientific Planning and Analysis. He cited three factors — all related to federal policies — responsible for his concern:

— Technically-based small companies have traditionally produced "a disproportionate number of innovative ideas," but now these companies are caught up in a tangle of increasing costs, regulation, and contract complexities. "The name of their game today is to reduce government support to a minimum and develop commercial, profitable products," said Mr. Morse.

— Similar trends are threatening technological innovation in large corporations, where, he says, "management emphasis is on 'return-on-investment' criteria, growth by acquisition, cost of capital, and inflation."

— By its policies for supporting science and technology in government laboratories, the defense/aerospace industry, that depend almost exclusively on federal research and development funds, we have created a "mammoth socialized research and development" establishment. Federal funding of scientific and technical information activities alone currently costs \$500 million a year, said Mr. Morse, and he said the effort now devoted to "paper studies, analyses, technological and economic forecasting, and overmanagement of programs is appalling." But "relatively little of the resulting management experience, technology, or extensive facilities can be applied to current national needs in such fields as transportation, energy, and housing, where market acceptance by the public and profit incentives for industry are essential," said Mr. Morse. "We have, in short, created an almost unlimited ability for the absorption of federal funds to analyze, study, and conduct research programs. . . without any regard for the criteria for approval that would be used by private industry." — J.M.

programs in the same way we manage basic research — that is, we make individual grants covering a relatively short time span even when the work itself is long-range in character. This process also tends to ignore the important design, manufacturing, and marketing problems that are brought into focus for consumers.

### Restraining the Research Universities

Among the important constraints to innovation in the U.S. is the serious plight of the major research universities that perform most of the fundamental and exploratory research that is the foundation for technical innovation. In spite of welcome increases introduced by President Ford at the last moment into the budget for the National Science Foundation, the federal research and development budget for fiscal 1977 must result in further retrenchment of ongoing activities and increased financial pressures on research-intensive institutions such as M.I.T. Research and development funds measured in real dollars have been shrinking (because they have failed to keep up with costs) for several years, and student support provided by the federal government has also been drastically cut. As an added burden, most institutions have also had to finance federally- and state-mandated programs which add significantly to the cost of operations. All this causes an almost unmanageable financial overload, with the result that fiscal control and budget cutting have begun to take priority over educational excellence, innovation, and student and public welfare.

Our research universities are the best in the world. They provide the bulk of the fundamental knowledge upon which our modern scientifically-based industry is dependent. Much of what we expect technology to provide in the future requires new understandings and new inventions and will be slower in coming unless the inexorable retreat of these institutions can be halted.

### Social Overhead and Closed Options

These specific difficulties may look disparate, but I am convinced that taken together they all contribute to the slowing down of the innovative process. The United States has moved in recent years from a situation in which all our forces, commercial and public, encouraged the innovation which created our spectacular scientific and industrial capabilities to a situation in which there are ever-increasing deterrents to creative change so that technical developments are much slowed down. This was to some extent inevitable and in some fields even desirable, but to a considerable extent it constitutes a social overhead which the nation cannot afford. Failure to meet problems we already see could be very costly — just in money, if we are lucky; but failure could mean many closed options, a retreat from our present level of well-being instead of continued progress toward a better society.

Fortunately these problems are not insoluble. The nation has great technical and industrial capabilities waiting to be more fully challenged, ideas waiting to be exploited. Bringing them together would contribute significantly to the economic well-being of the country and could be important to our nation's survival.

The role of technology in society has been a subject of continuing concern and inquiry by Jerome B. Wiesner as M.I.T. president and, previously, as Provost and then Dean of Science at M.I.T., and as Science Adviser to President John F. Kennedy. This essay is based on his keynote address to a conference on innovation and productivity arranged by the M.I.T. Club of Washington, D.C., early this spring.

# New Strategies to Improve Productivity

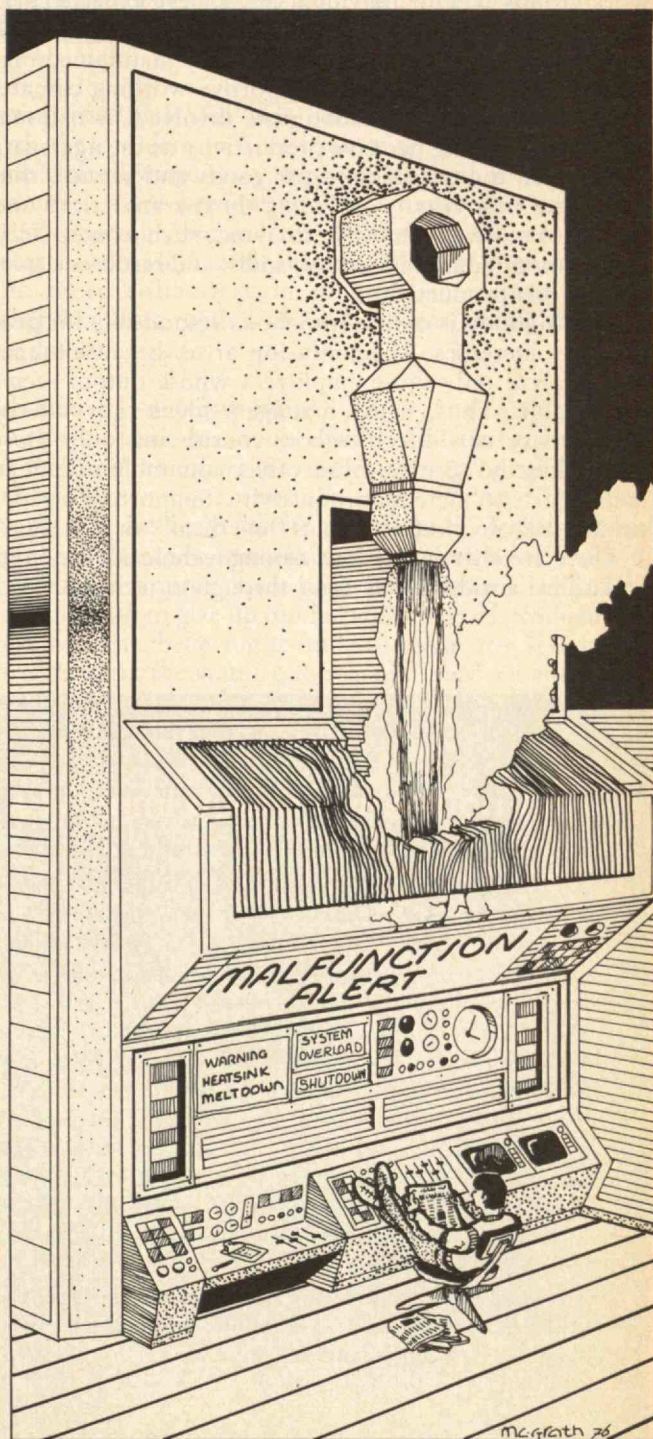
Over the past several years a large gap has developed between the rhetoric and accomplishment in improving productivity. In our surveys, informal discussions, conferences and workshops, a variety of managers have told us that even with an all-out attack on the problem, they can hope for only a five-to-eight-per-cent gain in productivity. And they expect even this improvement to erode almost entirely within two years — typically, they say, because of the great difficulties in sustaining the efforts of lower and middle managers and supervisors.

## Threats, Bribes and Productivity

These managers also concede they have run out of options. The only approaches they can consider are the familiar ones that depend on exhortation, threats, bribes, pressuring lower-level supervisors, and instituting more intensive organizational "communications." Most still believe that the only methods open to them to improve productivity are to automate, to get tougher with employees and unions, or to apply tighter controls, better standards, and more precise measures. These options show that they are convinced that productivity improvement requires a top-down approach. Yet these same managers acknowledge that traditional strategies yield only modest and short-lived gains. Their discussions about productivity improvement are filled with expressions of frustration, cynicism and futility.

Economists tell us that substantial and lasting productivity increases would constitute a strong counterforce to inflation. Moreover, such achievements would conserve our dwindling resources and enhance our ability to compete, especially with foreign businesses. Increased productivity could free the human and economic resources needed to improve our environment, develop cost-effective mass transportation, and renew our cities. With improved productivity, people could satisfy simultaneously their desires for both more income and more leisure.

Most American managers rank productivity improvement high on their lists of achievement priorities. Yet significant results are not apparent. People are no longer moved by U.S. Steel's full-page advertisements, and television commercials exhorting them to raise productivity, or by a ballad about productivity sung by a well-known country and western singer courtesy of the National Productivity Commission. The U.S. appears to be lagging behind most of Western Europe and Japan in the rate of productivity increase over the past several years. The absolute level of U.S. productivity actually has declined in



the past few years. Is American management throwing up its hands in the face of what is perhaps the most critical problem of our time?

### Productivity Undefined

There are at least six reasons for this sorry state of affairs. Reason number one: *There are too many loose definitions of productivity.* Everyone knows that with materials, tools, time, money, and know-how, people can turn out useful goods and services. Such outputs are termed "production" and the capacity to generate them can be referred to as "productivity." But productivity takes on different meanings depending on one's frame of reference or the "lens" through which one looks.

The industrial engineer setting work standards or piece rates focuses his lens on the efforts of individuals or small work groups. Yet no individual can achieve expected performance standards without proper training or the required tools or materials, with poorly maintained machinery, or in a hostile, nonsupportive working climate. At the other extreme, economists involved in national income accounting perceive productivity as the aggregate value of all the transactions for goods and services that take place in a year — including those transactions and consequences we would like to avoid, such as auto accidents, smog-induced illness, oil spills, and resource depletion. Is this productivity?

Also, nobody is quite sure who is responsible for productivity increases. The confusion arises because managers analyze only those employees whose output seems measurable. Thus, many managers focus only on the productivity of "direct" labor, considering only those who "directly" control observable, countable output in their efforts to increase productivity. Supporting personnel are still often referred to as "overhead" or "burden."

There are also distinctions among technical, economic, and social productivity. Seen through a technical lens,

productivity is the achievement of what is theoretically possible, assuming plenty of resources in the service of a pure technological discipline. However, in the real world of shifting wants and scarce resources, we cannot afford to indulge in pure, *technical* productivity. We must scrimp, postpone, sacrifice, select and trade off — and, thus, compromise with technical productivity in order to achieve *economic* productivity.

The output that results from a reconciliation of technical possibility with economic feasibility must also be desirable output that consumers will pay for, that is, *social* productivity. These three distinct viewpoints of productivity — technical, economic and social — often blur managers' considerations of productivity. The resulting confusion further hinders effective productivity strategy.

### Productivity in a New World

The second reason for management's failure to achieve substantial and lasting productivity gains: *Traditional strategies no longer work because our society has changed radically in the past several decades.*

Organizations could once be managed as relatively closed systems. Meeting organizational goals mostly meant linking funds with technology and know-how, and then driving the entire enterprise with managerial power. Labor was at a comparative disadvantage and therefore more "manageable"; output was geared to orders already in hand, rather than to estimated future demand; the political environment was one of *laissez-faire*; and a broad consensus on social values provided a climate of support for free enterprisers and for top-down management.

Today this "closed system" and its environment are gone. Technology, money and managerial power are still necessary, but they must now be applied in a climate of powerful unions, uncertain market demands, complex

## An Engineering Group Improves Productivity

A 13-member joint union-management committee, representing an innovative approach to achieving substantial and lasting improvement in both the quality of work and productivity of its engineering staff and support personnel, has been at work since June, 1974, in the Transmission Planning and Engineering Division of the Tennessee Valley Authority. The committee includes employee representatives of the major sections, key management members, and representatives of the two unions involved. A consultant team serves as principal resource to this committee, helping them formulate their program agenda, advising them in implementing this agenda, and helping them function effectively as a mechanism for constructive change in the division.

Among the improvements which have been achieved: instances of work duplicated in other divisions have been identified and eliminated; the employee performance ap-

praisal process has been revised so that performance reviews now reflect reality and require two-way dialogues between employee and supervisor; a process for appraising managerial and supervisory performance has been instituted; divisional and departmental committees have established guidelines for delegating technical decisions; a merit award process based on peer review has been introduced to recognize outstanding performance; the working arrangements for some 45 employees on field survey assignments have been revised to provide more time at home, greater teamwork, and higher productivity; and the process of gaining environmental clearance has been streamlined.

The committee is now examining the divisional organization and work flow to improve the utilization of employees, to reduce rework, and to improve productivity and work satisfaction. — A.J.

government regulations, and vigorous social criticism.

Compare, for example, the U.S. automobile industry today with what it was in the first three decades of this century. Never before has the industry borne such a weight of standards of environmental pollution, safety, and employment. Nor did early auto companies have to respond to rapid changes in energy economics, to increasing union demands for greater control over working hours and conditions, or to more aware and militant consumers. Gone are the days when a Henry Ford could prosper while dictating both to his customers and his employees what they would get.

Today's organizations differ notably from pre-World War II organizations. Consider the employees: once relatively hungry and deferential, workers have become more affluent, argumentative and alienated. People want to be defined by their lifestyle rather than by their job. They pride themselves on their uniqueness, rather than on their ability to fit in. Respect for authority is less automatic. Education levels, skills, and mobility are higher. These changed values appear to be little affected by the current recession.

The managers, too, have changed. They know that simple commands don't work as well as "the engineering of consent," in which demands and lecturing must give way to explanations and dialogue. They know that concern with their own bailiwick and with here-and-now internal needs is not enough; long-run, external factors impacting the organization demand equal attention. These managers are also finding that piecemeal and sequential approaches to solving problems are less effective than systemic approaches. And they are learning the advantage of solving problems by taking a "clinical" approach, rather than trying to place blame.

We know of one case where the president of a major coal mining company was becoming increasingly frustrated with steadily declining productivity in most of his 16 mines. Replacing some of his mine superintendents and transferring other managers and staff people seemed to have no effect. Much blame was placed on a new mine health and safety act that was being vigorously enforced. The president tried to relieve his frustration by tightening his control over mine operations, telephoning detailed directives to his mine superintendents from his office, 100 to 400 miles away.

Not until the president and his senior managers changed their perception of the causes of declining productivity did the situation begin to improve. They recognized that the new mine safety act was only one of many changes that were having a significant impact:

- Technology of mining equipment had become much more sophisticated with an increasing emphasis on electronic and hydraulic systems.

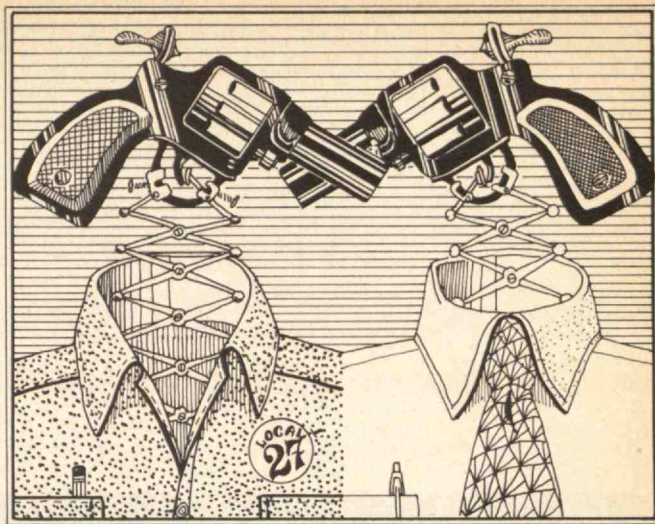
- The union was engaged in an internal struggle for leadership that heightened local factionalism.

- New union contract provisions had the effect of increasing turnover on the less desirable jobs in the mine.

- A substantial portion of the workforce was unlike the traditional miner . . . these younger men were better educated, more challenging of authority, and more independent and mobile, although quite inexperienced.

- The younger, better educated middle-managers were feeling constrained by the tight controls imposed on them.

After realizing the drift of these changes, the president instituted a new, more successful productivity improve-



ment strategy which was multi-dimensional and dealt with the problem in a systemic way. The new strategy emphasized employee, supervisory and management training; more preventive maintenance; an enhanced safety program; better labor relations at the mine level; greater delegation and accountability in management; and more collaboration in problem-solving across functional lines, with a sharing of ideas among the various mines.

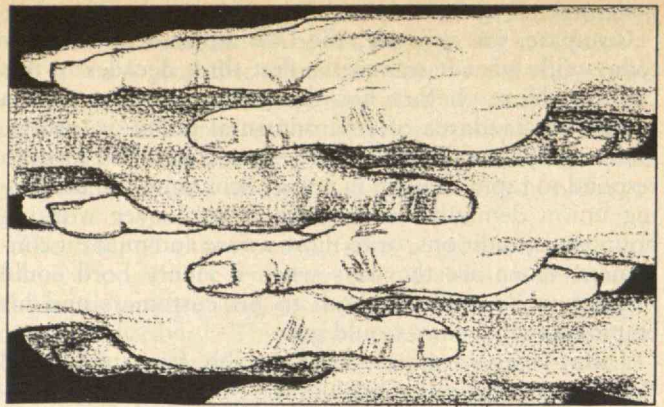
### Productivity: A Nasty Word

The third reason for management's difficulties: *To union leaders and members productivity improvement programs have negative connotations of speed-ups and layoffs.* Unions have therefore perfected defensive rather than collaborative strategies when confronted with a productivity improvement program. Knowing this, managers now often give up on the whole idea of productivity improvement, believing it futile to make any serious efforts to upset the status quo where unions are involved.

### A Confusing Yardstick

The fourth reason for management's difficulties: *In designing fresh approaches to improving productivity, the "hangup" is the issue of measurement.* Everyone knows that before embarking on any productivity improvement strategy, you must be able to measure changes in productivity in an agreed upon way from an agreed base. You must be able to detect improvement! But managers often show too great an appetite for precision and perfection. When they find it difficult to obtain such precision, as with "indirect," managerial and service functions, they throw up their hands, complaining, "I know there's plenty of opportunity for improvement, but how can we even get started when we can't quantify our present performance level?"

Such frustration can be paralyzing, especially considering that the service and "indirect" sectors of our economy have been growing more rapidly than manufacturing. Also, the number employed in activities that are difficult to measure is substantially greater than those engaged in "direct" manufacturing operations. However, even when precision *seems* easy (as in certain manufacturing operations) it is in fact every bit as difficult, because the hard-to-measure support functions are already embedded in the performance of the "easy-to-measure" operations.



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No economist, engineer or accountant has yet been able to pro-rate jointly created revenue among those who helped bring it about. Thus, the division-of-credit problem is one of "fair bargaining," not one of "mathematical proof." The risk inherent in bargaining is one of the things managers are paid for. Just as it is possible to find one's way out of a wilderness without ever knowing the precise longitude and latitude of the place where one is lost, so one can know that he has made productivity gains without being able to prove their precise magnitude.

Our experience has shown that even where "precise" measurement is supposedly possible, closer inspection reveals that the managers have fallen victim to considerable self-delusion. For example, measures of "individual" output actually measure the productivity of the *entire* organization *at that one point*; each individual depends on other functions and services for training, tools and materials, etc. Furthermore, employees often stunt the results of measurements, restricting their output for fear of higher standards, reduced employment opportunities, or other possible worrisome outcomes. Such "slow-downs" occur especially when the complexity of the measuring system arouses suspicion.

Every virtue claimed for any particular productivity measurement system has a dangerous flaw. For example, incentives based on piece-rates are often too effective at encouraging the worker to consider himself to be in business for himself. Then, this "independent businessman's" behavior may begin to cause problems for other parts of the organization of which he is an interdependent part. He may begin to cut corners on quality, skimp on machine maintenance procedures, squirrel away finished work to provide for a rainy day, and so on.

Managers must use measurement more for its motivational potential than for its potential for accounting precision. Measurement must be regarded as an entrepreneurial risk, not a science. A manager must ask himself or herself: "Shall I be content with whatever motivation I can get out of the sharpest measurement tool I can find; or shall I use whatever measurement approach gives me the highest possible motivation for the employees?" We emphatically favor the latter.

### Leaning on Technology

The fifth reason why many executives are unable to find new ways to raise productivity: *Management is overdependent on technological improvements.* Although past productivity gains have been achieved mainly through technological improvements, this approach is no longer,

enough. It is becoming increasingly expensive to achieve productivity improvement through further applications of sophisticated technology, and the results are more and more likely to be disappointing. For more complex technologies, the technicians involved, and not the technologies themselves, determine the benefits from the large capital investments.

For instance, one leading American manufacturer introduced a new machine designed to operate at twice the speed of existing equipment. Management expected this technological advance to reduce labor costs substantially and increase productivity dramatically. But with the conversion complete, results were disappointing. Labor costs increased more than 25 per cent and productivity only slightly; there was an almost 40-per-cent drop in machine efficiency.

The reasons? The more complex new machines required a longer training period for the operators and considerably more maintenance. Because after conversion there were only half as many machines as with the replaced equipment, the consequences in lost production due to a single "down" machine became much more serious. Waste and rejects increased dramatically when the machines were out of adjustment because they were produced at twice the prior rate. When faced with the new machines, the unions insisted on a substantial raise in pay rates for the new jobs, and the re-institution of some of the jobs that would be made redundant. The management of the company is now considering a productivity improvement strategy focused on behavioral change and motivation.

### Power by the People

The sixth reason why we are not continuing the productivity improvement established during the first six decades of this century: *Few managers yet recognize that realizing the full benefits from any productivity improvement means changing behavior at many levels in the organization.* This applies even to productivity improvements stemming from capital investment and technological advances.

New procedures or systems, tighter specifications, better employee and equipment utilization . . . all such changes associated with productivity improvement require changes in the behavior of all the workers: operatives, clerks, inspectors, maintenance personnel, accountants, sales and marketing staff, engineers, supervisors and managers. And the less the behavior changes to meet the new requirements, the less the productivity gains will

live up to their full potential. Of course, the need for behavioral change makes motivation a key issue. A person resists a change according to his perception of how much he may lose versus how much he may gain. His perception of this loss/gain ratio is strongly colored by how much he can influence the change.

#### **A New Productivity Strategy**

Since traditional approaches to improving productivity are disappointing, we need a new strategy, based on more contemporary assumptions. First let us see what new assumptions we need, and then let us propose some characteristics of a new productivity strategy.

The following nine assumptions, I believe, take account of the changes in our society since World War II and attempt to deal with our difficulties in improving productivity. They apply to all employees — management as well as “workers,” and must be considered as a total package.

— Improving productivity is an achievement of the total organization and must be validated by the market for the products or services.

— The basic pay given an employee assures only that he is available and that he will do just enough to preserve his contract with the employer. A worker or supervisor will no longer jump to increase his output on his boss' command.

— An employee's wage or salary bargain is constantly being renegotiated, implicitly or explicitly. Absenteeism, grievances, restricted output, etc., are forms of “invisible renegotiation.”

— Managers have greater leverage on productivity than do workers. Since management has the final authority, it has a never-ending responsibility for productivity improvement.

— Any productivity improvement is impossible without changing the behavior of employees. Management must win their consent, and guide their participation in problem-solving. A manager's request for suggestions will seldom produce anything helpful unless at the same time he directs the employees' attention to the areas needing work, explains the issues and provides any required information.

— An employee's consent is based on his perception of fairness, which means giving him access to the decision process, explaining to him what is happening and why and giving him the opportunity to renegotiate his contract with his employer. This consent also means giving him a degree of security, a reciprocal relationship with

## **Better Productivity in an Oil Company Distribution Section**

In Esso Petroleum Co., management — with help of consultants — used the techniques outlined in the accompanying article to greatly improve the productivity of their distribution operations in the United Kingdom in the mid-1960s. This project involved some 8,000 employees in 75 different operating locations and several thousand additional employees of more than 100 independent distributors. A new organization and top management team was developed to implement a multi-faceted strategy. The team designed and instituted a sophisticated management information system; revised the salary structure; provided new career opportunities; instituted management and supervisory training focused on the objectives of the productivity improvement program; and designed and negotiated a radically new labor union agreement that resulted in the abandonment of widespread restrictive practices. The result was to increase the motivation and upgrade the competence of a generally demoralized first-line and middle-management group. In addition, the labor union moved to increase its members' productivity: drivers agreed to operate their vehicles at an average speed of 40 miles per hour — compared with the previous 28, agreed to load their own vehicles — a task previously done by bulk plant personnel — and agreed to abolish the automatic requirement for drivers' “mates” and to operate vehicles and bulk plants on a double-shifted basis.

This new agreement, arrived at after more than a year of joint union-management work, enabled management to operate in ways far more cost-effective than before. Employees benefited from dramatically higher basic wages and from more leisure time gained through reduced systematic overtime — working hours per week were reduced from 60 to less than 43; they worked fewer hours without any loss in pay. The consequences of this are annual net savings in excess of \$10 million and an improvement in productivity in excess of 20 per cent, measured in terms of the utilization of both human and capital resources. — A.J.

management, and the opportunity to share in whatever gains may be achieved.

— Any measurement of improved productivity must use a method agreed upon between managers and employees. This is because, as we said earlier, it is impossible to separate precisely the relative worth of the various individual contributions needed to achieve improvements, which makes bargaining necessary.

— Managers must be prepared to compromise, because so many solutions are bargained.

— Any productivity strategy must be periodically revised. No strategy remains valid for longer than a few years without some adaptations to environmental changes — some of which are brought about by the strategy itself.

### Implementing the New Strategy

These new assumptions immediately suggest the operational characteristics of a new productivity strategy:

— It must include a considerable portion of the organization, perhaps all of it.

— It must be focused on behavioral change achieved through management-employee discussion and bargaining, with each self-interest served.

— It must include just about every variable that managers normally deal with, from technology to compensation to work flow.

— It must involve measurement aimed at motivating workers and only secondarily to appraise progress.

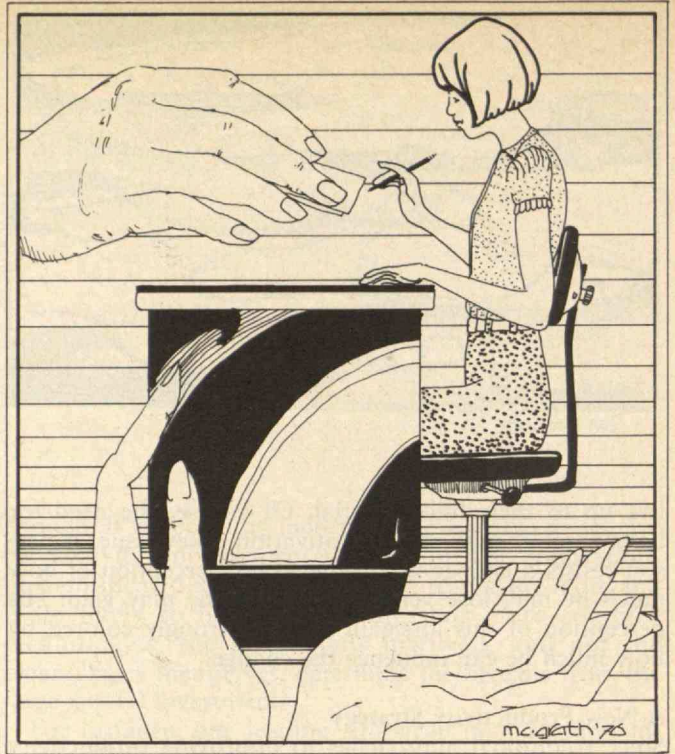
— There must be safeguards for both management and labor (e.g., trial periods, no-layoff clauses) as well as gain-sharing.

— The strategy must be addressed as a continuous challenge, not an episodic one.

— The strategy must enable everyone to share in whatever gains are achieved . . . management, labor, shareholders and the public.

To undertake a strategy suggested by the characteristics we've outlined, management must first be amenable to a bilateral approach to improving productivity. For example, does management believe that the relevant employees can help solve a certain problem no matter what their status or personal backgrounds? Can management accept criticism and challenges to its decisions? Is it willing to explain and debate the reasons underlying those decisions? Is it willing to share the gains resulting from productivity improvements? The answer to all these questions should be yes.

Although any productivity strategy will necessarily be unique, for any particular organization, some common



features emerge. For instance, management must take the initiative. Just as it is unreasonable to expect the impetus to come from any other party at the outset, so it is fatal to suppose that the initiative ever leaves management's hands all through the process of designing, developing, instituting, implementing and sustaining the new strategy. Another common feature is the multi-phase process in developing and applying such a strategy.

### Doing the Homework

The initial phase in this process (which may take up to a year) is a preparatory period during which management unilaterally does its homework, beginning with a preliminary assessment of the cost savings associated with various ways to improve productivity. Management can then define what its expectations should be, how much it is willing to pay to achieve the full potential gains and how much of the gains it will share. Management must analyze itself to determine how well it is prepared to undertake a bilateral, collaborative strategy. In making this assessment, a management examines its attitudes and values as well as its resources and skills. If management decides that it does have the opportunity, the appetite, and the wherewithal to continue, it may then want to prepare lower levels of management and supervision for a bilateral strategy. It may need to analyze the basic equity of the existing pay structure to identify weaknesses — as they could be accentuated by any bonus payments. A wise management will then identify all of its concerns and doubts, and define the areas where it wants to establish safeguards. Finally, management should study and determine past productivity experience in the organization.

### Bargaining for Productivity

Then comes the bilateral phase of developing the new strategy. Here, management begins to enlist the support of union officials (or other employee representatives), explaining to them the constraints and boundaries of the proposed strategy, sharing the data developed in the first

unilateral phase, and finally exchanging and discussing openly everyone's concerns. The "memorandum of agreement" emerging from these discussions can be used as a declaration of the strategy for sharing the gains from the productivity improvement. The memorandum includes a statement of the principles underlying the proposed strategy and an agenda for bargaining in the next phase. It supplements but does not supersede existing collective bargaining agreements and procedures. Then, management and the union(s) must examine the basic pay structure, focusing on its equity. Similarly, they should evaluate the readiness of both union and management leadership to implement the proposed new strategy. These studies may identify some issues for future negotiation. A representation procedure for conducting the business of the third phase should be decided, as well as a way to communicate progress to everyone involved.

#### Reaching Agreement

In a third phase, management and the union(s) work out the detailed agreement for implementing the new strategy. The agenda for bargaining may include: the scope for participation; how to measure improvement; safeguards; how to measure and share the gains; how to analyze the work and identify improvement opportunities; formula for representation; how to amend the design; and how to document and report productivity improvement. For each agenda item, options are developed and discussion held with the constituencies for both parties to gauge support for the plan. Some tests can be conducted jointly to work out agreement on remedying a weak precondition (e.g., a pay structure riddled with inequities) and on establishing safeguards for both parties (e.g., protection against redundancy for employees and protection against declines in quality for management). Agreement on each item is reached; a trial period and criteria for continuation of the program are specified.

#### Making It Go

In the fourth phase, the agreement is implemented jointly, if it has been ratified by most of the participants. Throughout this phase — which may continue indefinitely — managerial decisions and follow-through must be prompt and decisions and results must be widely disseminated. Early feedback on performance of the program should be provided. All suggestions must be considered, with comments made to the contributors — even if their ideas are rejected. Difficulties must be approached clinically without resorting to placing blame. Special at-

tention may need to be paid to first-line supervision, who must assume the leadership in defining many of the problems and opportunities to be addressed jointly.

#### A Managerial Challenge

I do not suggest that new productivity strategies be added to management's existing day-to-day work. Rather, I suggest a new, different way of doing what management currently does. For example, rather than devoting his time to answering questions put to him by higher-level executives and solving problems himself, the manager devotes more of his energies to identifying problems for relevant groups of employees to solve with his help — by asking questions and supplying needed information. Although using this approach it might take more time to reach some decisions, this time is regained when these decisions are implemented. A manager will in general be able to delegate the more detailed technical aspects of his responsibilities and spend more time coordinating resources for solving problems and helping employees develop their capabilities and their careers.

Can American managers shed their traditional values and attitudes and rise to the challenge posed by this new strategy? Without such a change, they will probably not be able to make this new strategy a success. Based on my experience, I am reasonably optimistic. American managers tend to be pragmatic. Once it is clear that traditional approaches no longer work, they are ready to consider new options. Also, the values and attitudes necessary to the success of the new strategy are in tune with the values and attitudes of contemporary American society, especially younger people. Thus, implementation of this new strategy will solve many of the problems so frustrating to today's management — problems such as absenteeism, tardiness, poor quality work, rework and waste, excessive grievances, turnover, and restrictive practices. Managers will find their own jobs more stimulating and satisfying. With the adoption of gainsharing, management, too, will benefit directly. The direction is clear. It remains for management to begin.

**Arnold S. Judson**, a senior staff member with Arthur D. Little, Inc., collaborates with business, unions, government, and non-profit institutions to introduce innovations in operations and management. He has worked with organizations in the U.S., Europe, and the Middle East. He holds an S.B. in chemical engineering, and an S.M. in the social and behavioral sciences and industrial relations, both degrees from M.I.T. Author of *A Manager's Guide to Making Changes* (John Wiley & Sons, 1965), he has also had extensive experience in manufacturing and personnel management in private industry.

# Returning to the Infinite Jail

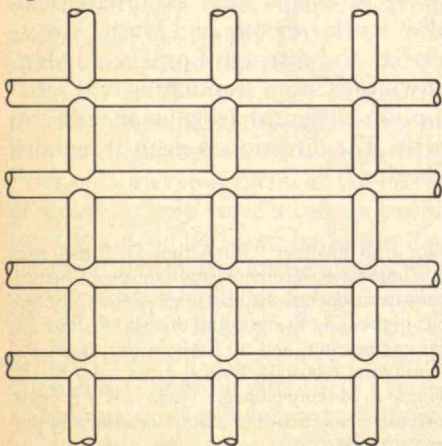
Puzzle Corner  
by  
Allan J. Gottlieb

Hello again. Although it is only the middle of May, I know that through the miracles of modern communication you think it is already August. These miracles partially account for the delay in seeing your problems in print. The greater delay, however, is that I have a fairly large backlog of problems. For this I am grateful. Let me be more specific, and thereby answer a number of reader inquiries: I have a large and growing supply of regular problems — well more than a year's worth. When added to the above-mentioned miracles, this means that any problems sent in today will not appear until 1978! For bridge and chess problems, however, the prospects are better — the backlog is just a few months. And "speed" problems — especially good ones — are in short supply.

We now have a second permanent problem; please see the solution to M/A 5, below, for details. And we continue the policy of presenting previously-unsolved problems — this time a problem explained to me by Mike Spivac (of *Calculus on Manifolds* and *Calculus Calculus Calculus Calculus Calculus Calculus* fame). It's shown below as NS 4, first published in February, 1969, as the 16th problem in Puzzle Corner for that volume of the *Review*.

## Problems

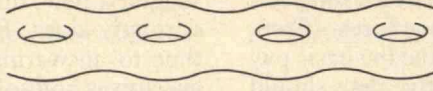
NS 4 Consider the surface of an infinite jail cell, which extends up, down, left and right:



and two infinite holed tori, one extending to the right:



and one extending to the left and right:



Are any two of these three homeomorphic? Why, or why not?

J/A 1 Our first new offering is a nine-part chess problem from Thomas O. Mahon, Jr.:

What is the minimum number of pieces required for a position in which

- A. If White is to move,
  1. The situation is a stalemate;
  2. White must win;
  3. Black must win. Or
- B. If Black is to move,
  1. The situation is a stalemate;
  2. White must win;
  3. Black must win.

The three requirements when White is to move combine with the requirements when Black is to move to create nine sub-problems. Two comments are in order: pieces include pawns; and the sub-problem A = 2, B = 3, for example, requires that when White moves first he wins for any sequence of legal moves, and similarly for Black.

J/A 2 Our second problem is from Irving L. Hopkins:

It is well known that Pythagorean triples with integers  $a$ ,  $b$ ,  $h$ , where  $a^2 + b^2 = h^2$ , may be generated by taking  $h = p^2 + q^2$ ,  $a = p^2 - q^2$ , and  $b = 2pq$ , where  $p$  and  $q$  are any integers such that  $p > q \geq 1$ . A special series of such triples is that in which the legs  $a$  and  $b$  differ by one unit. By means of a table of squares we can find that the first four of such triples are:

$p$	$q$	$h$	$a$	$b$
2	1	5	3	4
5	2	29	21	20
12	5	169	119	120
29	12	985	697	696

(For the tenth such triple,  $p = 5741$ ,  $q = 2378$ ,  $h = 38,613,965$ ,  $a = 27,304,197$ , and  $b = 27,304,196$ .) If we take the fractions  $q/p$  from the table above, they are  $1/2$ ,  $2/5$ ,  $5/12$ , and  $12/29$ . These are the continued fraction approximants for  $\sqrt{2} - 1$ . Prove that all the approximants (a) result in Pythagorean triples (b) with legs differing by unity, and (c) that the dimensions increase nearly geometrically with a ratio approaching  $(3 + 2\sqrt{2})$ .

J/A 3 Robert Pogoff wants a straight-edge-and-compass construction of a triangle given the lengths of the three medians.

J/A 4 Here is a number theoretic problem from Emmet J. Duffy:

Write down in a row the coefficients of the expansion of  $(a + b)^N$  where  $N$  is any integer. Multiply each coefficient by the second coefficient and set the result below the multiplied coefficient. Continue by multiplying by the third, fourth, and fifth coefficients, etc. An example is shown for the coefficients of the expansion of  $(a + b)^4$ :

1	4	6	4	1
4	16	24	16	4
6	24	36	24	6
4	16	24	16	4
1	4	6	4	1

Find a formula for the sum of the digits in any diagonal.

J/A 5 Stuart Schulman has supplied our last problem — a logic problem. It was brought to mind, he says, by the preface to a George Gamow book read many years ago. Gamow's problem involved three people who wanted to split a decanter of wine equally but had no measuring devices. Of course, with just two the solution is simple: one of them divides the wine until he/she is satisfied with either portion, and then the other is allowed to choose. With three people it gets a bit more complicated; Schulman's problem: Can the question be generalized to a larger number of people, by finding a way to divide the wine for any number so that each is satisfied that his/her share is (at least) a fair one? Assume that each person is willing to divide the wine and accept any of the portions.

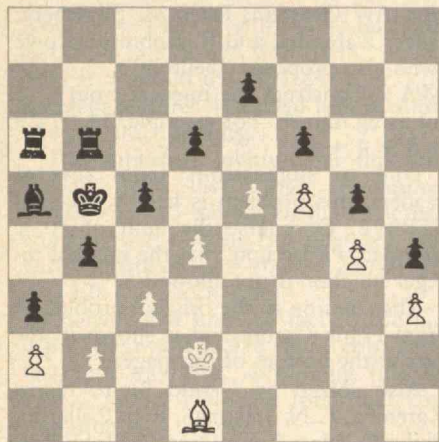
## Speed Department

J/A SD 1 P. V. Heftler wants you to find three primes A, B, and C such that  $A^2 + B^2 = C^2$ .

J/A SD 2 Winthrop Leeds wants you to explain how 64 units can be divided into three pieces which can be reassembled into 65 units (see right):

## Solutions

DEC 1 (as corrected in the March/April issue) White to play and draw:



The following solution is from S. J. Warner and Virginia S. Glessner:

1. B — R4 ch K × B\*
2. P — N3 ch K — N4
3. P — B4 ch K — B3
4. P — Q5 ch any
5. P — K6

The above results in a pawn blockade which cannot be penetrated; thus no further captures can be made.

\* If K — N5, then 2. B — N3 ch, etc., resulting in a perpetual check.

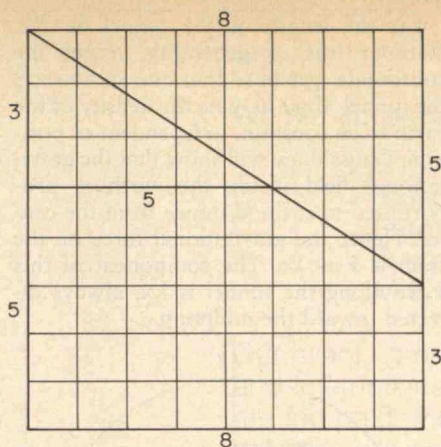
Also solved by William J. Butler, Jr., A. Le Blanc, Abe Schwartz, Herbert R. Moeller, Rony Adelman, Gerald Blum, Jerome J. Taylor, Ralph Menikoff, Ralph Wagner, and the proposer, Mike G. Middlebrooke.

M/A 1 South is declarer at a contract of six spades. How can he make the contract after West leads ♥K?

♠ J 10 8	♠ K Q 3
♥ A K 6 4	♥ —
♦ K J 7 4	♦ Q 8 3
♣ 7 3	♣ A K 9 8 6 4 2
♠ A 9 7 5 4 2	♠ 6
♥ Q J 10	♥ 9 8 7 5 3 2
♦ A 6 5	♦ 10 9 2
♣ 5	♣ Q J 10

Most readers noticed that in the problem as originally published East needed the ♣J and ♣10, added in italics above. Albert J. Fisher has submitted a solution which includes a few possible pitfalls:

The secret of my solution lies in the realization that North's clubs must be es-



tablished and that no end-play or throw-in against West can succeed if both West and South have hearts in hand when West is put on lead. Then it becomes clear that the whole problem is one of not letting the defense in too soon. All the schemes involving ruffing the third club low or pitching a heart suffer from this defect — the defense is in a position to make a damaging return which prevents South from drawing trumps and enjoying the established clubs. The way to prevent this is to set up the clubs by ruffing the third round with ♠A. The play goes as follows:

1. Ruff low
2. ♣A
3. ♣K, discarding a heart
4. Small club, ruffing with the ♠A.
5. Trump to the ♠K.
6. Small established club, discarding the last heart from South.

The position prior to the lead of trick 6. is:

♠ J 10	♠ K
♥ A x x	♥ — —
♦ K J x	♦ Q x x
♣ —	♣ x x x x
♠ 9 x x x	♠ — — —
♥ Q	♥ 9 x x x x
♦ A x x	♦ 10 9 x
♣ —	♣ —

By ruffing with the ♠A, South has established a trump trick for West. In return, however, he has gained a tempo: when South leads his good club and pitches his remaining heart, West is well and truly fixed. He can ruff in, but South can handle any red suit return, while the remaining spade in dummy serves the dual purpose of extracting the outstanding trump and providing entry to the rest of the club suit. If West elects to ruff in but throws off red cards, South rids himself of his losing diamonds, cashes his ♦A, and concedes one trump trick. One interesting feature of the hand is how few high cards North and South really need in order to fulfill this slam. If the hands had been

♠ K Q x	♠ x
♥ —	♥ x x x x x x
♦ x x x	♦ x x x
♣ A K x x x x x	♣ x x x
♠ J 10 9	♠ A x x x x x
♥ A K Q J	♥ x x x
♦ K Q J 10	♦ x
♣ Q J	♣ —

the evolution of the spade slam would proceed exactly as described above, unbeatable against any defense.

Also solved by Elmer C. Ingraham, William J. Butler, Jr., Jerrold Grossman, Jon Froemke, F. F. Schultz, R. Robinson Rowe, John Rollino, Avi Ornstein, Rick Collarini, Carl S. Kelley, and the proposer, Russell A. Nahigian.

M/A 2 Recall the Fibonacci numbers defined by:  $F_1 = F_2 = 1$  and  $F_{N+2} = F_N + F_{N+1}$  for  $N \geq 1$ . This sequence begins 1, 1, 2, 3, 5, 8, ... The problem is to prove that

$$\lim_{N \rightarrow \infty} F_{N+1}/F_N = (1 + \sqrt{5})/2.$$

Some people "cheated" by assuming that the limit exists and then calculating its value using the recursive formula for Fibonacci numbers. The hardest part, of course, is to show that the limit does exist. Nonetheless, a fine solution was submitted by Stephen Speicher:

Notice that expanding  $x/(-x^2 - x + 1)$  leads to

$$x + x^2 + 2x^3 + 3x^4 + 5x^5 + 8x^6 + \dots + F_N x^N,$$

where the coefficient of  $x^N$  is  $F_N$ , the Nth Fibonacci number. The general term for  $F_N$ , the coefficient of  $x^N$ , may be found as follows: Use partial fractions to express:

$$x/(-x^2 - x + 1) = A/(x - a) + B/(x - b), \quad (1)$$

where a and b are the roots of the equation

$$\begin{aligned} -x^2 - x + 1 &= 0; a = -(1 + \sqrt{5})/2, \\ b &= -(1 - \sqrt{5})/2. \end{aligned}$$

Then  $x = A(x - b) + B(x - a)$ , and by equating coefficients determine that  $A = -a/(b - a)$ ,  $B = b/(b - a)$ . Substituting these results into (1) and rearranging terms, the expression becomes

$$1/(b - a)[1/(1 - x/a) - 1/(1 - x/b)].$$

This term may be expressed as

$$1/(b - a)[(1 + x/a) + (x/a)^2 + \dots + (x/a)^N - [1 + x/b + (x/b)^2 + \dots + (x/b)^N].$$

This expression now shows that the

coefficient of  $x^N$ , which is  $F_N$  of the original expansion, is  $F_N = 1/(b-a)(1/a^N - 1/b^N) = 1/(b-a) \cdot (b^N - a^N)/a^N b^N$ . But  $ab = (-1)(1 + \sqrt{5})/2(-1) \cdot (1 - \sqrt{5})/2 = -1$ ; therefore  $a^N b^N = (-1)^N$ , and then  $F_N = (-1)^N/(b-a) \cdot (b^N - a^N)$ .

$$\begin{aligned} \text{Now } \frac{F_{N+1}}{F_N} &= \frac{(-1)^{N+1}/(b-a) \cdot (b^{N+1} - a^{N+1})}{(-1)^N/(b-a) \cdot (b^N - a^N)} \\ &= - \left[ \frac{b^{N+1} - a^{N+1}}{b^N - a^N} \right]. \end{aligned}$$

However, since  $b = -(1 - \sqrt{5})/2$  which is  $< 1$ , then the

$\lim_{N \rightarrow \infty} b^N = 0$ . Therefore

$$\frac{F_{N+1}}{F_N} = -(-a^{N+1}/-a^N) = -a = -(-1)(1 + \sqrt{5})/2 = (1 + \sqrt{5})/2. \quad \text{Q.E.D.}$$

Some additional points are worth noting. The number  $(1 + \sqrt{5})/2$  is, of course, the legendary golden ratio, used extensively by the Greeks in the proportioning of their artifacts and architecture, the best example being the Parthenon. This golden ratio,  $1 : (1 + \sqrt{5})/2$ , is seen in such simple figures as the sides of a golden rectangle, as well as a generator for more complex structures such as a logarithmic spiral. To elaborate on the use of the golden ratio and its relationship to natural phenomena could easily fill several volumes. More appropriate to M/A 2, however, is the realization that there was nothing unique in the choice of the Fibonacci sequence leading to the limit  $(1 + \sqrt{5})/2$ . Your readers might enjoy noting that any sequence of numbers formed according to the rule  $U_{N+2} = U_{N+1} + U_N$  will exhibit the property that the

$$\lim_{N \rightarrow \infty} U_{N+1}/U_N = (1 + \sqrt{5})/2.$$

The choice of the initiating sequence as being 1,1 (the Fibonacci generators) was entirely arbitrary. Using  $-5, 2$  or  $3, -1$ , etc., would produce the same limit as  $N \rightarrow \infty$ . One final note: It is interesting to see that the simplest of continued fractions

$$1 + \frac{1}{1 + \frac{1}{1 + \dots}}$$

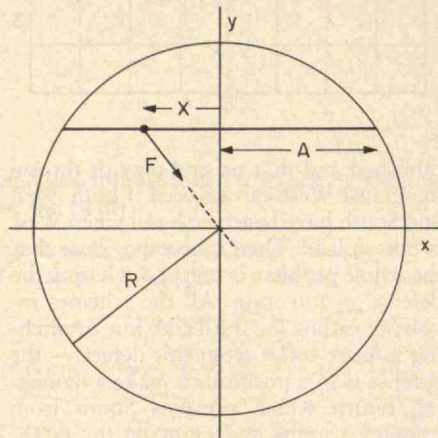
also has as a limit  $(1 + \sqrt{5})/2$ . This can be seen by forming successive convergents  $1, 2/1, 3/2, 5/3, 8/5, 13/8, 21/13, 34/21, \dots$ , which is easily recognized as being  $F_{N+1}/F_N$ .

Solutions also received from Mark Marinch, Hillary Fisher, Charles Gordon, R. Robinson Rowe, William J. Butler, Jr., Stephen P. Hirshman, Hank Lieberman, Peter M. Silverberg, Robert H. Bicker, K. Haruta, Arthur W. Anderson, Harry Zaremba, Gerald Blum, Frank Carbin, Philip O. Martel, and the proposer, John Prussing.

**M/A 3** A frictionless train runs by gravity in a straight tunnel between two points on the earth's surface. Find the maximum velocity and the time for a round trip. Show that the latter is independent of the length of the tunnel.

The following is from Richard Hanau:

Let the length of the tunnel be  $2A$ . Without loss of generality, orient the coordinate system so that one axis bisects the tunnel. If we assume the density of the earth to be constant, independent of position, Gauss' Law will show that the gravitational field inside the earth is proportional to  $r$ , the distance from the center. Hence the gravitational force on the train is  $F = kr$ . The component of this force along the tunnel is  $kx$ , always directed toward the midpoint.



Because  $F_x = -kx$ , the motion is simple harmonic motion with amplitude  $A$ , and the equations of simple harmonic motion can be used. (This assumes the train starts at the surface of the earth with zero velocity.) The maximum velocity, which occurs at the midpoint, can be found by equating the total energy at the midpoint (all kinetic),  $mV_{\max}^2/2$ , to the total energy at the surface (all potential),  $kA^2/2$ . (The motion is frictionless.) Hence  $V_{\max} = A\sqrt{k/m}$ . To evaluate  $k$ , note that at the earth's surface, where the acceleration due to gravity is  $g$ , the gravitational force is  $mg = kR$ . So  $k = mg/R$ , and  $V_{\max} = A\sqrt{g/R}$ . Hence all trains, of different masses, have the same maximum velocity — indeed, the same motion — in a given tunnel. The time for a round trip is the period,  $T$ , of the simple harmonic motion. Since  $V_{\max} = 2\pi A/T$ , we have  $T = 2\pi\sqrt{R/g}$ , independent of the length of the tunnel.

Also solved by F. N. Steigman, Emmet J. Duffy, James P. Ballard, Robert Pogoff, William J. Butler, Jr., Stephen P. Hirshman, Arthur W. Anderson, Harry Zaremba, Gerald Blum, and the proposer, Jack Parsons.

**M/A 4** A palindrome is a word or a sentence which spells the same thing when

spelled backwards — “rotator,” for example, or “Madam, I’m Adam.” What about a word to describe a word (or a sentence) which spells another word (or a sentence) when spelled backwards — for example, “devil, sung”?

I present everyone’s solutions together: “rewarder,” “deveiled,” “reflowed,” “deflower,” “retooler,” and “deserts” are eight letters. The winner is “deliverer” (nine letters). The solvers were Joyce Tang (a “drow”), Albert J. Gracia, Rick Collarini, Avi Ornstein, Peter M. Silverberg, Harry Zaremba, and R. Robinson Rowe (who also proposed “beiltog”).

**M/A 5** Construct the integers from 1 to 30 using four 4s. For example,  $14 = \sqrt{4} + 4 + 4 + 4$ .

Due to suggestions from several readers, this problem is hereby declared **PERM 2**. Of course the limit of 30 is dropped. Please note that the greatest integer function is not allowed.

The solution to the original problem is from Frank Carbin and is shown in the box at the bottom of this page.

Also solved by Gerald Blum, Harry Zaremba, F. N. Steigman, Rick Collarini, Philip O. Martel, Avi Ornstein, John Rollino, Donald Zalkin, Richard Williams, Mark A. Frahlman, Naomi Markovitz, Wendy Elane Erb, J. D. Miller, Stuart D. Casper, William J. Butler, Jr., George Ropes, Peter M. Silverberg, John Kavazanjian, Paul Manoogian, David Finkel, William G. Hutchison, Jr., and the proposer, Bill Saidell.

#### Better Late Than Never

**O/N SD 1** Clifton N. Lovenberg and Joan Young point out that Mr. Horvitz’s solution should be amended to say that one quarter of the children of Aa children will be aa.

**DEC 2** J. David R. Kramer has solutions for  $K = 5$  and  $K = 13$ . Can anyone find a procedure for all  $K$  (or at least for infinitely many)?

**DEC 4** Dr. Prussing points out a typographical error in his printed solution. Move “/6” from the second line of his formula to the end of the third line.

**DEC 5** R. Robinson Rowe has improved on the published solution:

The task is accomplished by establishing depots at way points for caches of fuel in 25-gallon units. If  $n$  units are cached at the first depot, one unit is used to deliver  $n - 1$  units to the next depot. This requires

- |                                |                               |                            |
|--------------------------------|-------------------------------|----------------------------|
| 1. $(4 \times 4)/(4 \times 4)$ | 11. $(4! + 4! - 4)/4$         | 21. $(4.4 + 4)/.4$         |
| 2. $4/4 + 4/4$                 | 12. $(44 + 4)/4$              | 22. $4! - (4 + 4)/4$       |
| 3. $(4 \times 4 - 4)/4$        | 13. $(4! + 4! + 4)/4$         | 23. $(4 \times 4! - 4)/4$  |
| 4. $4 + (4 - 4)/4$             | 14. $-.4 + 4 \times (4 - .4)$ | 24. $4! + (4 - 4)/4$       |
| 5. $(4 \times 4 + 4)/4$        | 15. $4 \times 4 - 4/4$        | 25. $(4 \times 4! + 4)/4$  |
| 6. $(4! + 4 - 4)/4$            | 16. $4^4/(4 \times 4)$        | 26. $4! + (4 + 4)/4$       |
| 7. $4 + 4 - 4/4$               | 17. $4 \times 4 + 4/4$        | 27. $4! + 4 - 4/4$         |
| 8. $(4! + 4 + 4)/4$            | 18. $(4 \times 4! - 4!)/4$    | 28. $4 \times (4! + 4)/4$  |
| 9. $4 + 4 + 4/4$               | 19. $4! - 4 - 4/4$            | 29. $4! + 4 + 4/4$         |
| 10. $(44 - 4)/4$               | 20. $4! - 4 + 4 - 4$          | 30. $(4 \times 4! + 4!)/4$ |

$n - 1$  round trips and a final one-way trip aggregating 250 miles, so the leg between depots is  $250/(2n - 1)$  miles. The next leg will be  $250/(2n - 3)$  miles, and the system continues until a final leg of 250/1 miles reaches the goal at Mile 1000. The total distance covered is

$$L = 250 \left( \frac{1}{2n-1} + \frac{1}{2n-3} + \frac{1}{2n-5} + \dots + \frac{1}{1} \right)$$

$$= 250 \sum_{i=1}^n \frac{1}{2i-1} = 250 \phi(n).$$

Now  $L = 1000$  if  $\phi(n) = 4$ , but since  $\phi(418) = 3,999\ 495\ 848\ 5098 \dots$  and  $\phi(419) = 4.000\ 690\ 591\ 6401 \dots$ , the problem requires 418 ideal legs as above and one fractional leg.

The published solution put this fractional leg last and consumed 10474.982 735 gallons of fuel. The best strategy is to put the fractional leg first, with a length of  $L_o = 1000 - 250 \phi(418) = 0.126\ 037\ 8726$  miles.

To deliver 418 units of fuel to the first depot, there will be 418 round trips and a final one-way trip, consuming fuel for  $837L_o$  miles. Thus the total fuel consumption is

$$G = 418 \times 25 + 837L_o/10$$

$$= 10450 + 837[100 - 25\phi(418)]$$

$$= 94150 - 20925 \phi(418)$$

$$= 10460.549\ 369\ 932\ 44 \text{ gallons,}$$

Continued on p. 72

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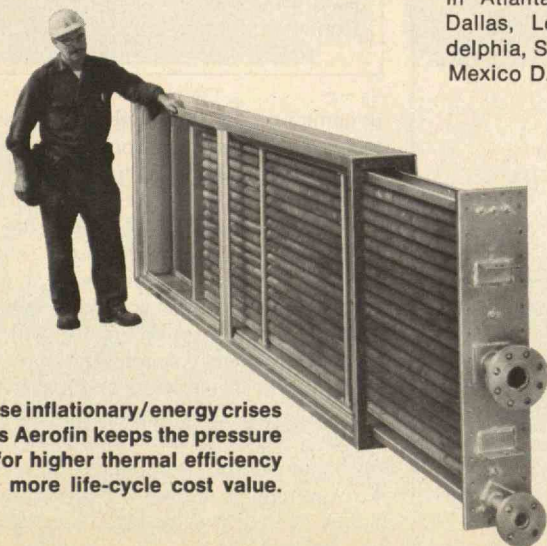
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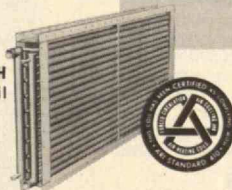
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which is nearly 15 gallons less than the published solution.

Mr. Rowe has appended a demonstration of the computation of  $\phi(n)$ , for which space is not available. Readers may obtain copies on request from the Editors of the Review, Room E19-430, M.I.T., Cambridge, Mass., 02139.

M/A SD 2 Robert Pogoff points out that the given solution is good only for low altitudes.

The following have responded to the problems indicated:

PERM 1 Gerald Blum.

NS 2 A. C. Lawson and Bruce Simon.

O/N 4 Hans P. Lieb, Frederick Smalkin (a farmer, most appropriately), and John Young.

JAN 2 N. Spencer.

JAN 4 A. W. Collins.

FEB 2 Neil Hopkins.

FEB 4 Hans P. Leib.

### Proposers' Solutions to Speed Problems

J/A SD 1 Mr. Hoftler did not supply a solution, so I will tell you why none is possible. We must have either three even numbers or one even and two odd numbers. Since  $2^2 + 2^2 \neq 2^2$ , we are reduced to  $A^2 + 4 = C^2$  or  $A^2 + B^2 = 4$  with A, B, and C odd. The latter is clearly impossible, so consider the former. Let  $A = 2N + 1$  and  $B = 2M + 1$ . We require  $(2N + 1)^2 + 4 = (2M + 1)^2$ ; i.e.,  $N^2 + N + 1 = M^2 + M$ , which is impossible (M must be greater than N but  $M = N + 1$  is too big).

J/A SD 2 The picture is a beautiful cheat! The grid is a little warped and the large triangles are really (noncongruent) quadrilaterals.

Allan J. Gottlieb is Coordinator of Computer Activities at York College of the City University of New York. Send Problems, solutions, and comments to him at York College, 150-14 Jamaica Avenue, Jamaica, N.Y., 11451.

## Letters

Continued from p. 3

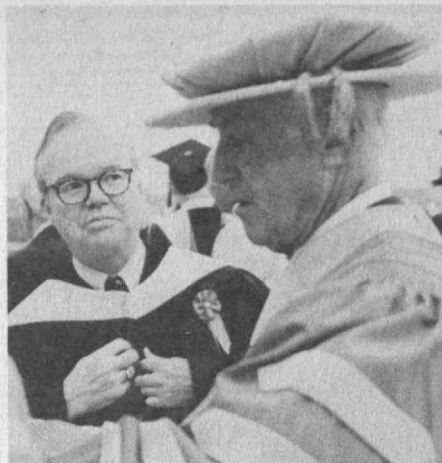
dynamics model, is available as a basis for study and for use in choosing among alternative policies. The human and economic penalty for unwise governmental policies is potentially so staggering that the country can ill afford to "muddle through." Just concerns about dynamic models of social and economic behavior should not cast doubt on our ability to deal with social complexity at a time when public frustration and uncertainty are increasing. Instead, the opportunity to reach a better understanding of social problems should spur an accelerated effort to improve models for clarifying economic change and for evaluating alternative policies.

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# Commencement



*Commencement is a special time for the principals (top: Howard W. Johnson, left, Chairman of the Corporation, and John J. Wilson, '29, Chief Marshal), the graduates, and the alumni (bottom, left to right: Breene M. Kerr, '51, James R. Killian, Jr., '26, David A. Shepard, '26, and Dr. William G. Austen, '51) (Photos: Owen D. Franken, '68)*



## 1,467 Diplomas to a New Generation of Graduates; Their Challenge Is Better Management, says President Wiesner

Some 1,300 graduates received 1,467 new M.I.T. degrees from President Jerome B. Wiesner at the 110th Graduation Exercises on May 28. It was a sparkling, cool spring day — just the kind of day which tradition says should be provided for such an important academic festival.

A special message from President Wiesner to the 3,000 family and friends who crowded Rockwell Cage: "This is the one day of the year when our favorite expression, 'the M.I.T. family,' takes on its deepest possible meaning. . . . There is no adequate way to express appreciation for what you have done to help make this day possible."

And to the graduates, Dr. Wiesner said, "Though it may be a bit unfashionable to talk of excellence and hard work, M.I.T. still pays homage to these virtues. So on this occasion it is appropriate to congratulate you on your accomplishments — that is, on your abilities and what you have done with them. . . . For each of our newest generation of graduates it is a time to celebrate the completion of a difficult and important course of personal development.

"The greatest challenge we face," Dr. Wiesner said, "is that of managing our technology more effectively, but doing it in ways that preserve the diversity, freedom, and initiative of our people and institutions, industrial and educational." (A digest of Dr. Wiesner's address to the graduates appears on pages 76 and 77.)

For a remarkable number of graduates,

it was a celebration truly within the M.I.T. family. Herbert M. Federhen V, whose S.B. degree was in computer science, was the third generation of his family to attend M.I.T. His father, Colonel Herbert M. Federhen IV, '49, also studied electrical engineering. And Herbert's grandfather, Herbert M. Federhen III, '20, graduated in chemical engineering.

Elizabeth King, '76, whose S.B. was in architecture, turned out to be the wife of John G. King, '50, Francis Friedman Professor of Physics who is Associate Director of the Research Laboratory of Electronics.

No one has counted how many of the graduates were children of alumni; eight were children of members of the faculty — Mark D. Abkowitz, '74, Ned C. Forrester, '75, Ethan E. Jacks, '76, Jonathan D. Lettvin, '76, Robert Lambe, '76, Curtis R. Menyuk, '76, Neil E. Rasmussen, '76, and Paul F. Robbins, '76.

### Alert at the Podium

Of the 890 bachelor's degrees awarded, 179 were in the fields of electrical engineering and computer science — traditionally the largest of M.I.T.'s 24 degree-granting departments. Next came the life sciences, in which 130 bachelor's degrees were given. That's an unprecedented 15 per cent.

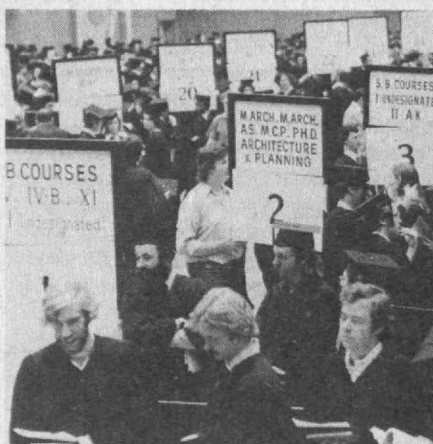
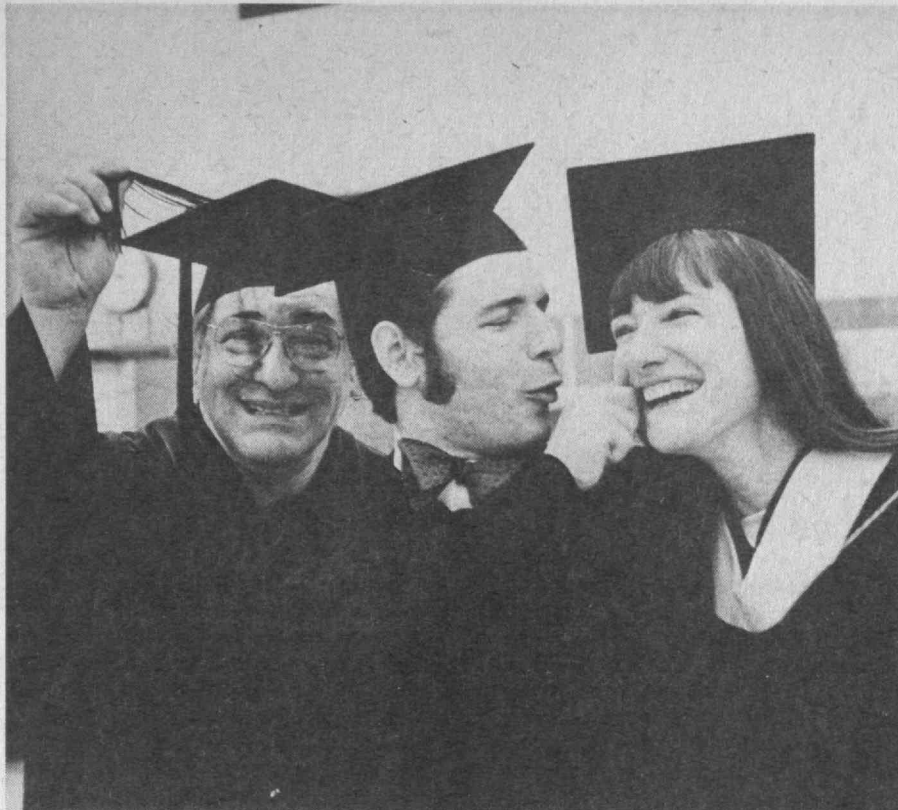
As usual, each graduate received his own diploma — and, if a doctorate, his hood — as he marched across the podium in Rockwell Cage. The logistics to make that possible are impressive, carefully calcu-

lated, almost foolproof. As he enters Rockwell Cage in the academic procession, each graduate gives his/her name to a checker, to be verified against a list of the diplomas carefully stacked by the lecturn.

This year one checker reported one student missing. His name was lined out of the list to be read by the Dean of his school, and his diploma was quietly drawn out of the stack as the ceremonies began. But he wasn't missing: up he came in turn. An alert Registrar retrieved the set-out diploma, an alert Dean read the name which had been noted as "Abs," and the ceremonies proceeded.

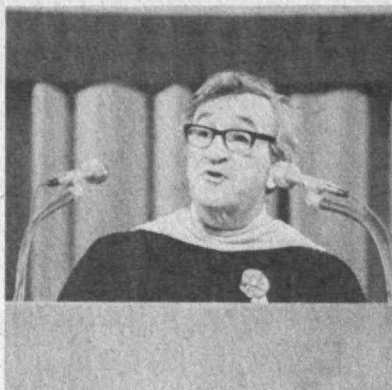
The heartiest applause of the day was for Ramon Ramirez Lomelo of Guadalajara, Mexico, who received a master's degree in political science. He is blind, and his wife escorted him across the podium to receive his degree — just as she had been by his side throughout his years at the Institute.

Appearance at the Graduation Exercises is not obligatory; many graduates are off to jobs or summer adventures during the week between the end of final examinations and Commencement — a period required for the faculty to submit grades and the Registrar to compile them. But this year, thinks Professor Frank E. Perkins, '55, who served as Marshal of the Graduates, more students than usual chose to participate in the pageantry and celebration. A sign of the times? □



Commencement personalities: (opposite) Professor Roy Lamson at the President's Reception for the graduates; (top to bottom, this page) Professor and Mrs. Jerome Y. Lettvin with their son, Jonathan (S.B., physics); Professor Frank E. Perkins, Chairman of the Committee on Commencement; David A. Shepard, '26, Marshal of the Corporation; and Professor and Mrs. John G. King (Mrs. King received the S.B. in art and design; her husband is Francis Friedman Professor of Physics). (Photos: Owen D. Franken, '68)





## "The Joy of Life Is at Least as Much in the Journey as in the Goal"

*The following is a digest of the address by President Jerome B. Wiesner to members of the Class of 1976 at the Institute's 110th Graduation Exercises on May 28:*

Graduation is above all a joyous occasion. For each of our newest generation of graduates it is a time to celebrate the completion of a difficult and important course of personal development. Though it may be a bit unfashionable to talk of excellence and hard work, M.I.T. still pays homage to those virtues. So on this occasion it is appropriate to congratulate you on your accomplishments — that is, your abilities and what you have done with them.

To help me focus my thinking for today, I conducted an informal mini-poll, asking some members of your Class and some faculty members what they would like to hear about. Not surprisingly the response almost always focused, in one way or another, on the future and on the more-than-usual uncertainty that people, young and old, feel about it at this time. The issue was put to me most interestingly by one of your colleagues who expressed it in terms of her alternation between hope and despair, her inability to weigh the countless events — large and small, hopeful and discouraging, good and bad — that demand her attention each day. She found it difficult to derive from them even a *consistent* view of the future, much less an enduring sense of hope.

I am sure that this audience and most of the reasonably well-informed inhabitants of the world share this bitter-sweet sense of confusion as they try to imagine what the next half century will bring. Can we venture a picture of even the next decade that we can agree upon?

I should say at the outset that I am basically hopeful, and this morning I will try briefly to tell you why. Fundamentally, I *believe* that, in a halting way, with many ups and downs, humanity is struggling

forward toward a more satisfying life for people. The resulting pull between hope and despair is one which women and men have always confronted. The challenge for those who want to be active in the struggle is to maximize the ups and minimize the downs. Let me see if I can show you what I mean.

My sense of (cautious) optimism is based on three things: the positive balance of our national strengths and weaknesses; the continuing opportunities provided by science and technology, tempered by our increasing recognition that they have costs as well as benefits; and the emphasis on the role and well-being of the individual that exists today.

### Balancing Freedom, Responsibility

In assessing our future, especially in this bicentennial year, we turn first to our past. History allows us to look back on our nation's origin and ponder our strengths and weaknesses, our achievements and errors — and there is much there to give us hope. We are the beneficiaries of one of the most successful experiments in humanity's long history. Our ancestors created a uniquely effective engine for personal, social, and economic development which we perhaps appreciate too little. Consequently, we have the natural and human resources and industrial capabilities to continue to lead the way to a more satisfying life if we can "put it all together," so to speak.

On the other hand, we have paid a very substantial price for these achievements in terms of separation from nature, changing human relationships, the spectre of nuclear annihilation, and the threatening concentrations of governmental power, to mention just a few, and we should support the various counter-trends developing in the society. I draw comfort from the fact that much of the present turmoil is the result of an effort to find the proper balance between

the urge for freedom and the need for responsibility at all levels in the society.

In the sixties, the conviction was developed that our society could treat *everyone* much better, support *every* need, and quickly rectify *every* trouble and inequality. In the process of trying to meet all these expectations simultaneously the great engine that is the United States economy was taken for granted, became seriously overworked and faltered.

Now we have the task of putting it back to work and matching our demands to its capabilities. To do this, we will need to develop consensus on some goals and accept a substantial degree of self discipline, both group and individual. Because of the inherent strengths in our democratic society, I weigh in on the side of hope in the choice between hope and despair.

The roles of science and technology loom large in any discussion of modern society, and particularly any examination of future prospects. I have time for only a few thoughts on this subject.

Although there is genuine basis for the frequently expressed fear of large-scale technology, I am convinced that there is no other viable option for humanity. In fact, the tradeoffs have been and remain very much on the positive side. I doubt that many of us would prefer the living conditions of 1776 or 1876, if examined realistically, or even those of a typical traditional — i.e., underdeveloped — society today, to those of contemporary life.

A successful technologically-based society is — must be — a dynamic, learning system in a continuing state of change and evolution, requiring new technologies and new organizational forms, new relationships, and probably even new lifestyles as it evolves.

Many people find this premise troublesome, for they have been hoping that the world might one day — sooner rather than later — approach a steady state in

which change, especially technologically induced change, would cease. Sad to say, they, and we, must accept the fact that there is not likely to be a stable state in the sense that new problems won't arise, demanding in turn new technologies and social inventions for their solution.

But there is no reason why change must be traumatic. Our goal should be to do things better, with less impact on the environment, less burden and danger to the individual, less expensively, more reliably, and with more emphasis on individual well-being. In fact, I predict that humanistic and environmental issues will dominate decisions in the years ahead. In the future, there will be much less social and human dislocation caused by new technology. Let me explain this. The highly industrialized nations of the world have entered a new phase of their evolution, in which new technologies must increasingly be what I would call sophisticated *replacement* technologies. New energy technologies, energy conservation techniques, systems to improve environmental quality, and technologies to increase food production are all in this category. Replacement technologies do not carry with them the severely dislocating effects on huge numbers of people which initial technologies did. Rather they seek to correct, if anything, the social effects of first-generation technologies. The likelihood of producing violent, traumatic discontinuities by the introduction of new technologies is also considerably smaller because societies are learning to be on guard against such occurrences.

I am not saying that there cannot be other threats as serious as the invention of nuclear weapons, perhaps in the life sciences, but rather that the effects of new *industrial* technology will be much less disorienting. In fact, I suspect that any serious discontinuities which may occur are much more likely to be of a degenerative character, the result of the

failure to have new technologies available when needed. The failure, for example, to develop alternative energy sources or to meet food needs, obviously would have very damaging effects on the conditions of life.

The biggest problem in the future may be how to make things happen. For the needed new technologies to exist, long-range actions of many kinds are required that go beyond our current capabilities — for example, research and development with a long lead time, effective ways of choosing the most promising among a great variety of possible long-term goals, and incentives for innovators, especially those in industry, even when the rewards are deferred for a long time.

The greatest challenge we face is that of managing our technology more effectively, but doing it in ways that preserve the diversity, freedom, and initiative of our people and institutions — industrial and educational. I have confidence in the American people's ability to meet this challenge.

#### **Looking Inward in Search of Purpose**

Most hopeful to me of my three proofs against despair is the increasing number of individual citizens who are taking the time to become knowledgeable about the major issues of the day — the many people, young and old, who have learned to insist that ultimate human values always be weighed along with economic benefits, however difficult this may be. During my lifetime there has been a continuous trend in this direction, strengthened by a growing conviction that there is in our country a synergism between individual and collective welfare.

My graduation, 40 years ago, was at the time of the Great Depression. Though I cannot remember who the commencement speaker was, much less what he said(!), I do remember that there was suffering on a scale unknown to

many here today. There were no jobs for college graduates or anyone else. Unemployment was 25 per cent. There was little welfare and no unemployment insurance. Hitler's mad voice was rising. Despair then was deep, worldwide, and — perhaps most important — deeply fatalistic. Forty years ago, massive malfunctions of the economy and the severe suffering that accompanied them were thought to be inevitable.

Clearly there has been much social and economic progress in those 40 years. Perhaps most important, following World War II we exchanged the earlier fatalistic view of life for one even a bit overoptimistic — the view that we merely had to define a problem and legislate a solution in order to solve it. At the moment, we are on the rebound from that attitude; we are in the maturing phase of realizing that there are very few solutions that don't require persistence and continuous learning. But on the positive side, we have a better-educated nation than ever before. We appreciate increasingly that the joy of life is at least as much in the journey — in the doing, in the quality of the experiences along the way — as in the goal. We as a nation are looking inward for our sources of strength, hoping to rediscover a worthy national purpose.

All of you who graduate today have shown great natural talents, a strong desire to learn, an ability to concentrate your efforts. Very many of you, too, have demonstrated a strong sense of personal responsibility and a deep concern for the well-being of other people. You will find plenty of opportunities in the decades ahead to put these varied talents to work. You will also find many frustrations. Ours is a society which challenges you to be a problem solver, to keep on learning, to keep on trying. For each of you, there is much to do that is worthy of the best that you can give. What other reason do you need for hope? □

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If you were receiving a doctor's degree in M.I.T.'s 110th graduation exercises on May 28, these are the instructions you received from Professors Frank E. Perkins, '55, and David C. Major, Marshals of the Graduates:

1. When the Dean says, "Doctor of Philosophy (or Science) with all the rights and privileges thereto," upon the calling of your name step forward and receive the degree with your left hand from President Wiesner. *Do not shake President Wiesner's hand.*

2. Then remove your cap with your right hand, at the same time bowing to President Wiesner, and step in

front of the rostrum where Dean Wadleigh (right) and Chancellor Gray will be waiting. There you should turn around and, keeping the body upright, bend slightly at the knees (particularly if over 6 feet!) while the hood is placed over your head. (Members of the armed forces are not to wear the hood over your uniform. Instead, you will accept the hood with your right hand and then place it over your left arm.)

3. When the hood has been properly adjusted, replace your cap, tassel now on the left front side and return to your seat.

## Dorms to Barracks — R.O.T.C. Graduates

An officer stopped in front of one young man in inspection. "Son, do you really enjoy jumping out of airplanes?" "No, sir, I hate it." "Then why are you here?" (It was a volunteer unit.) "Well, I like to be with those who do."

Shared experience is extremely important in the military, explained Major General Rush B. Lincoln, S.M. '35, former General Manager of the Massachusetts Bay Transportation Association, in his address at R.O.T.C. graduation this spring. Twenty students received commissions — ten in the Army, eight in the Navy, two in the Air Force. Five more will be commissioned in the Army following six weeks of summer camp of Fort Bragg, N.C. Major General Lincoln's advice to them:

"As you go through the service you will find you will be offered choices. I suggest you don't plan where you want to be, but do the best job you can and those that have interesting work will look for you.

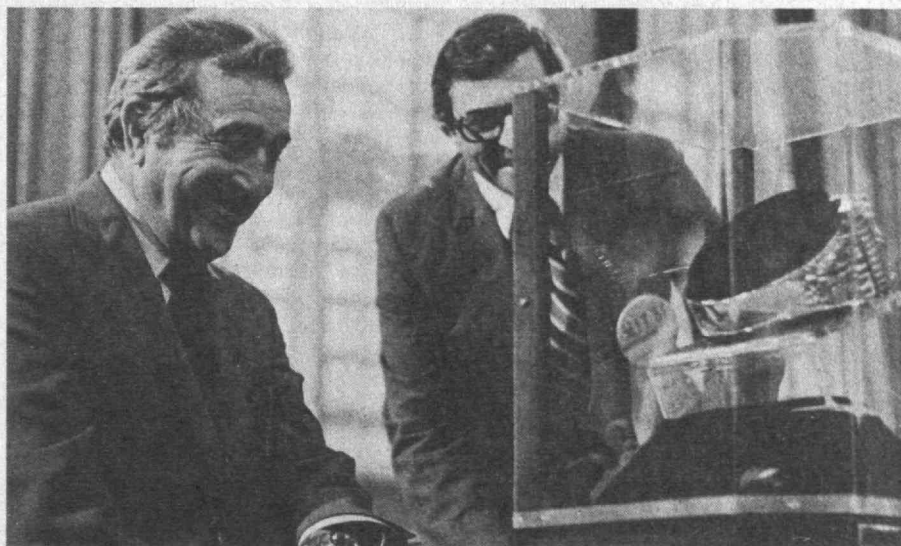
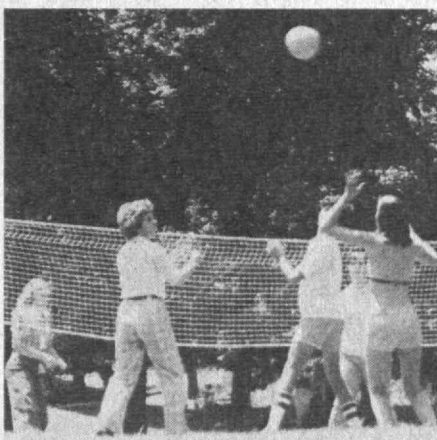
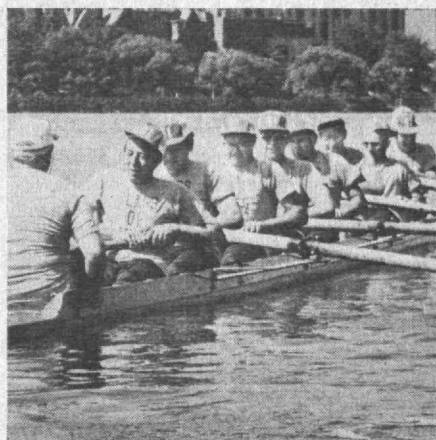
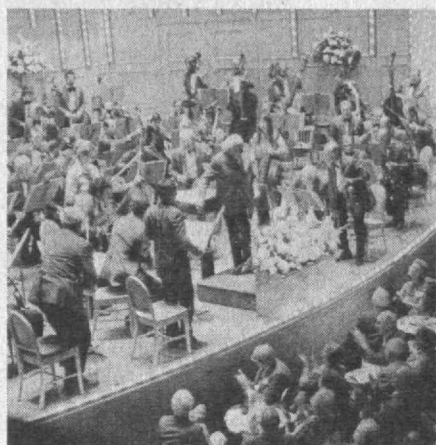
"Confidence is your greatest strength.

You will only develop as you accept new challenges. Take advantage of any opportunity you have. The combat role gets the most accolades, and justly so. But logistics is important — and this is a rewarding career that covers every aspect of life.

"Employ business school principles: analyze, organize, deputise, and supervise. Don't forget you're dealing with people — be compassionate, when necessary, firm when necessary, and fair. While you are on active duty, consider yourself as a military liaison with the civilian community. You will have better information available than the average citizen — you should share it with him."

In the midst of his solemn words of wisdom, Major General Lincoln was also able to smile at some people's image of the military. He described a cartoon: "I don't want to be surrounded by a group of yes men!" says the officer talking to a group of subordinates. "I want men who say yessir!" □

# Technology Day



*Technology Day highlights (top to bottom): Tall tales of how it used to be. Arthur Fiedler at Tech Night at the Pops. The Class of 1951 after 25 years. Volleyball at '51's Salem clambake. The Class of 1926 gift came from outer space, with a little help from Charles S. Draper, '26, and his secretary, Peggy Mooney. The 6½-pound sterling silver brass rat attracts President Jerome B. Wiesner (the proud observer is Howard L. Livingston, '51, Co-Chairman of his Class Reunion Gift Committee. Photos: John I. Mattill, Marjorie Lyon, Calvin Campbell, and Darrell J. King, '72)*



## Record Reunions: A Six-Day Indulgence of Fellowship and Nostalgia

The rebirth of nostalgia? The lure of touring bicentennial landmarks? A new sense of confidence in the future as well as in the past — and perhaps also in technology? A growing loyalty, after a half-decade of dissonance?

Whatever the reason, alumni returned to M.I.T. in record numbers for 14 class reunions, countless class and departmental mini-reunions, and the all-Institute Technology Day between June 1 and 6. Some 1,500 graduates and members of their families registered; of those, 950 adults and 230 children were housed on the campus. Institute housing overflowed into a nearby hotel, and some of the children slept in a room above the du Pont gymnasium reserved for visiting teams. The demand for seats for "M.I.T. Night at the Pops" with Arthur Fiedler conducting, the opening event of Technology Day, exceeded by several hundred the seating capacity of Symphony Hall.

According to Joseph J. Martori, Director for Alumni Services — he was chief of logistics for the week — 1,100 people came from more than 50 miles away, some from as far as Costa Rica, Nicaragua, Venezuela, and Iceland.

There were cocktail parties, brunches, banquets, receptions, meetings — even seminars and lectures. Salvatore Lauricella, Assistant Director of Food Services, estimates that he and his associates were responsible for wining and dining 8,750 people at 65 different events on the campus in the six-day period.

A few unusual events in unusual places: a cruise on Boston Harbor (1921), an evening

at a dinner theater (1921), an "art tour" of the campus (1941), several turn-outs of crews to relive rowing on the Charles, a sunny picnic on the beach in Barnstable (1971), a bicentennial ball inaugurating Pier Four's new "atrium" restaurant (1951), a clambake at Rivers Country Day School (1956), a special reunion of "Old Logs" to join today's Logarithms for beer and harmonizing, an orchestra for old-time jazz dancing at McCormick Hall, a bus tour of the North Shore with box lunches of rock Cornish hen (1921) . . .

Some participants were treated to an instant replay: Rivalyn Zweig, Administrative Assistant for Alumni Services, videotaped some events so everyone could see what it looked like almost while it was happening. (The real purpose was to record this year's action to help next year's reunion committees make their plans.)

Things were popping for nearly a week at Historical Collections, where the warm reception contrasted with the dusty warehouse surroundings. "We fed about 600 people, and about 200 more stopped by," says a delighted Warren Seamans, Director. That means his group's many exhibits attracted almost half of all the week's visitors, and Mr. Seamans is now busily following up many offers of memorabilia.

Other highlights of the week:

—Members of the Class of 1931, at a gathering in McCormick Hall, unveiled a portrait of Margaret Hutchinson Compton, their guest of honor. Mrs. Compton is the widow of Karl Taylor Compton, ninth M.I.T. President, and she has been an honorary member of the class — the first to be

graduated during Dr. Compton's tenure — since 1931.

The portrait was the joint project of President and Mrs. Jerome B. Wiesner, Howard W. Johnson, Chairman of the Corporation, and Mrs. Johnson, and former President Julius A. Stratton, '23, and Mrs. Stratton. It was executed by Yousuf Karsh, famous Canadian photographer, and will hang alongside a Karsh portrait of Dr. Compton in the office of the Alumni Association's Executive Vice President.

—Dr. Irwin W. Sizer, Professor of Biochemistry, Emeritus, former Dean of the Graduate School, was made an honorary member of the Class of 1924.

—Dean William L. Porter of the School of Architecture and Planning announced the establishment of the Lawrence B. Anderson Fund, in honor of the Dean Emeritus of the School, and said it had reached \$49,200. The fund will be used to enhance the educational experience of students in the school through the support of projects that draw not only on the students' academic achievements but on their non-academic achievements as well. Dean Anderson received a three-dimensional plaque surfaced with brass and containing his initials and other information about the dedication, designed by Maurice K. Smith, Professor of Architecture.

There was also lots of free time — free time to see Boston's bicentennial sights, time to tour the campus, time to relive old times, and time to think about the past, the present, and the future — and how it seems to mean different things to different people.



Reunion memories (left to right):  
1951's reception at the President's House.  
The Technology Day luncheon — largest in  
history.  
Professor Jay W. Forrester, S.M. '45,  
speaks to the Class of 1931.  
A visit to M.I.T.'s Historical Collections  
Signing up for the children's program.  
(Photos: John I. Mattill, Calvin Campbell,  
and Darrell J. King, '72)

(Below) President Jerome B. Wiesner and  
Breene M. Kerr, '51, Reunion Gift  
Co-Chairman, test the "heft" of that  
record-breaking "brass rat." (Photo: Calvin  
Campbell)

## \$7.4 Million for M.I.T.: The Largest Reunion Gift Comes with the Largest "Brass Rat"

A few of the dollars were counted more than once, but President Jerome B. Wiesner's enthusiasm was understandable: he left the rostrum of the Technology Day luncheon on June 4 having heard about at least \$7.4 million of alumni giving to M.I.T.

The biggest news of the day came first. In a well-rehearsed duet, Breene M. Kerr and Howard L. Livingston, Reunion Gift Co-Chairman for the 25-year Class of 1951, maintained the suspense as long as they could: no class has had larger reunions on its fifth, tenth, 15th, 20th, and now 25th anniversaries; no class has better learned the lesson of an M.I.T. education: "the freedom to achieve is the motivation for success"; no class has devised more — and more innovative — ways for its members to support M.I.T. . . .

. . . and no class in the history of American higher education has given so large a 25th reunion gift: \$1,451,300. It is the total of giving to the Institute by 615 members of the Class since its 20th reunion; it is "the strongest kind of endorsement of private higher education"; and its purpose is "to make sure there is one institution, here at M.I.T., that is the best and will remain the best," said Messrs. Kerr and Livingston.

(Frederick G. Lehmann, '51, Director of the Alumni Fund, thinks this \$1.451-million gift holds the record by topping a \$1.376-million reunion gift by the Yale Class of 1950 last year.)

Then came another surprise: Mr. Kerr stepped forward to unveil what turned out to be the largest ring ever cast in precious

metal — a replica of the M.I.T. ring in sterling silver, eight inches in diameter, weighing 6.4 pounds. No lesser symbol, thought 1951's Reunion Gift Committee, would be appropriate to commemorate this remarkable occasion.

### Rededication to Excellence

Escorted by minutemen from Sudbury and Bedford, Mass., whose presence symbolized the bicentennial spirit, Edward L. Dashefsky, '36, came forward with a 40th reunion gift of \$481,000 — the contributions of 262 classmates during the five years since 1971.

Then came Thornton W. Owen, '26, and — from the back of the hall — an "astronaut" bearing what turned out to be a symbolic \$902,800 gift from the 50-year Class of 1926. Why an astronaut? Because one of the class heroes is Professor C. Stark Draper, '26, whose principles of inertial guidance made possible the Apollo missions to the moon, and because \$200,000 of the gift was to endow a scholarship honoring Professor Draper and his achievements. (The "astronaut" turned out to be Professor Draper's favorite secretary, Peggy Mooney.)

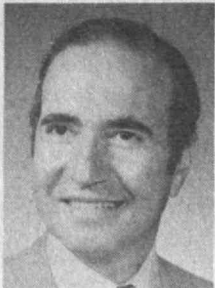
In addition, \$50,000 of the Class of 1926 gift was designated for a new wing for the M.I.T. Sailing Pavilion, and the remaining amount of the gift was for unrestricted scholarships. And 49 members of the class, said Mr. Owen, have reported estate plans which include bequests to M.I.T., the value of only a portion of which is now estimated



at over \$2 million.

Finally, a surprise announcement from Jasper B. Carr, '16: in ten years since the Class of 1916's 50th reunion, its members have given M.I.T. \$1,603,318 — a record-breaking 60th anniversary gift, he said.

When he returned to the rostrum, Howard L. Richardson, '31, President of the Alumni Association, added still more good news. As of June 4, the 1976 Alumni Fund stood at \$2,980,000 — an all-time high for any Alumni Fund on that date, 22 per cent ahead of the 1975 Fund. Responding to this outpouring of generosity on the part of alumni, President Jerome B. Wiesner said that M.I.T. is proud of its alumni and proud that the Institute's role in their lives justifies such confidence and generosity. The gifts will encourage the Institute, he said, to "re-dedicate ourselves to the standards of excellence which you knew — standards even harder to sustain today than in an earlier time," Dr. Wiesner thinks. □



C. W. Brenner



E. D. Callahan



K. F. Gordon



S. M. Proctor



C. H. Spaulding



E. L. Wick

## Alumni Association: Seven New Leaders

Edward O. Vetter, '42, who retired in 1975 as Executive Vice President and Principal Financial Officer of Texas Instruments, Inc., Dallas, is President of the M.I.T. Alumni Association. He's one of seven new officers of the Association chosen by its 1975 National Selection Committee, and he will serve a one-year term as head of the 60,000-member group devoted to supporting and advising the Institute.

Other officers whose choice by the Selection Committee was announced at the Technology Day luncheon on June 4:

— Claude W. Brenner, '47, former Vice President and General Manager of Laser Graphic Systems Corp., Waltham, Mass., Vice President of the Association for two years.

— Emerson D. Callahan, '48, founder and Director of TR Communications, Inc., Hasbrouck Heights, N.J., Director of the Association for two years.

— Kenneth F. Gordon, S.M. '60, Special Assistant to the Director of the Office of Telecommunications, U.S. Department of Commerce, Director of the Association for two years.

— Stanley M. Proctor, '43, President of

Stanley M. Proctor Co., Cleveland, Vice President of the Association for two years. — Charles H. Spaulding, '51, President of Spaulding and Slye Corp., Boston, Director for two years.

— Emily L. Wick, '51, Dean of the Faculty and Professor of Chemistry at Mount Holyoke College, Director for two years.

All those chosen have been active in alumni affairs. Mr. Vetter is a member of the M.I.T. Corporation, and he's been a member of its Executive Committee since April. Dean Wick is a member of the Corporation Visiting Committee on Student Affairs, and Messrs. Proctor and Vetter have been members of the Alumni Fund Board.

Introduced at the Technology Day luncheon, Mr. Vetter said he believes the Association represents "the most powerful community of technological skill in the world today. . . . When the role of science and technology is so crucial to the humane solution of so many global problems — population, food, health care, and energy, to name a few — we are dependent on the skill and involvement of this group more than any other I can think of." □

## Selection Committee

Four members of the Alumni Association have been chosen in the Association's 1976 election to serve for three years on the National Selection Committee. They are:

— Philip H. Peters, '37, Chairman

— Russell N. Cox, '49, representing District 1 (Greater Boston)

— Dean L. Jacoby, '54, representing District 2 (Northern New England other than Greater Boston)

— M. Louise Curley, Ph.D. '46, repre-

senting District 4 (New York City and New Jersey)

They will join other members of the Committee in 1976-77 to select alumni nominees for the Corporation and the national officers who will serve the Association beginning in July, 1977.

Though the ballots specified a deadline of May 15, polls in the election were held open until June 15 because the distribution of ballots was delayed. □



The gavel signifying leadership of the M.I.T. Alumni Association is in new hands. Edward O. Vetter, '42, formerly Executive Vice President and Chief Financial Officer of Texas Instruments, Inc., received it at the Technology Day luncheon on June 4 from Howard L. Richardson, '31 (left), retiring President of the Association. Mr. Vetter's term of office extends to July 1, 1977, and he told over 1,200 alumni at the luncheon that the Association represents "the most powerful community of technological skill in the world today," and he is "proud to be your president." (Photo: Darrell J. King, '72)



P. H. Peters



R. N. Cox



D. L. Jacoby



M. L. Curley

## How the Class of 1931 Learned What's Wrong with their Congressmen

After 45 years of trying to understand the world into which M.I.T. propelled them, members of the Class of 1931 seemed fully receptive to the reunion message from Professor Jay W. Forrester, S.M. '45, on June 3:

Putting it in terms of differential equations — a third-order system can simultaneously show oscillation and growth, for example — our national economy is a 1,000-order system. No person can solve a fourth-order system by inspection, and it is therefore essentially impossible, said Professor Forrester, to understand and analyze the complex interconnections between sectors and levels in our economic system.

Hence Professor Forrester's efforts to develop system dynamics: to replicate in a computer the complex interconnections between variables in human systems — companies, cities, nations, even the world — and then to isolate and study the effects of individual variables.

Because social systems, for example, show many different modes and types of behavior, attempts to look at them piecemeal — one mode at a time — are

"frought with the possibility of misunderstanding, . . . drawing conclusions from the wrong evidence and applying corrections to the wrong sectors." The power of system dynamics, he thinks, is the ability to substitute "a consistent systemic understanding for a vastly contradictory body of information."

### Cattle and Machine Tools

Professor Forrester — he is Germeshausen Professor in the Sloan School of Management and, as Associate Director of the Servomechanisms Laboratory 25 years ago, designed Whirlwind I (M.I.T.'s first high-speed digital computer) — told the Class of 1931 that "I'm not really an engineer at all"; he's a "fugitive from a Nebraska cattle ranch." Now his system dynamics studies of the U.S. national economy confirm what he knew from his youth: to increase production, you have to decrease production first.

On a cattle ranch, that observation is simple to understand: to raise beef production, you have to have more cattle. To have more cattle you must have more calves. To have more calves, you must have more

cows. And to have more cows, you must — for a while — have less beef.

The same thing in the nation's capital goods sector: to have more goods, you must have more machines. To produce more machines, you must — for a while — produce fewer goods. Professor Forrester calls such a process "highly destabilizing," and he thinks it is responsible for a 14-year cycle in the price behavior of beef, and indeed for some aspects of the cyclical behavior of an economy as a whole.

How do you know you're right? asked a friendly skeptic in the Class. That's not really a fair question, replied Professor Forrester: there is no real "proof" of Ohm's Law — it simply seems to work over the range of values to which we apply it. The same thing seems to Professor Forrester true of his models: in analyzing the behavior of the national economic system and seeking ways by which we can make it work better, system dynamics is simply "competing against the model in the head of your Congressman," he said. □

## Edward O. Vetter is Under Secretary of Commerce

Edward O. Vetter, '42, (left), accompanied by his wife, was sworn in as Under Secretary of Commerce in Washington July 7 by U.S. Secretary of Commerce Elliot L. Richardson.

"Ed Vetter is uniquely qualified for this position. His 28 years of business experience have given him valuable familiarity and competence in such wide-ranging areas as international trade, energy development, science and technology, capital formation, trade in the Mideast, and East-West relations," Secretary Richardson said.

Mr. Vetter will continue as President of the Alumni Association — he expects to maintain an active role in Association affairs.

He counts his technical background among the important qualities he will bring to the Department of Commerce, where he thinks there is a "growing realization that technology is perhaps our most important resource in the U.S."

Mr. Vetter is the first person with an



engineering-business background to serve as Under Secretary of Commerce since the mid 1950s. As the second-ranking officer in the Department of Commerce, he will be involved in all Department activities, which include pro-

motion of foreign trade, energy problems, economic affairs, maritime affairs, patents, minority enterprise, standards and weights and measures, ocean and weather research, and travel promotion.

As construction began on the new Walter C. Wood Sailing Pavilion (left), George Warren Smith, '26, received an M.I.T. sailing coach's jacket from Ross Smith, Director of Athletics (right), at the Technology Day luncheon. Under Mr. Smith's leadership, alumni contributed over \$285,000 for the new pavilion and a new fleet of "Tech Dinghies" (see June, p. 77). Opposite: Charles S. Draper, '26, (left), Emeritus Institute Professor and Professor of Aeronautics and Astronautics; David A. Shepard, '26, Class President; James R. Killian, Jr., '26, Honorary Chairman of the M.I.T. Corporation at a class reception at the President's House; Margaret H. Compton with Dr. Wiesner at the unveiling of her portrait.



## Twenty-five Year Survey: Millionaires, Drop-outs, Peanut Butter and Jelly

Twenty-five years out of college — how do they feel about their lives? The Class of 1951 is, by and large, "a contended group," write Samuel Rubinovitz and David I. Caplan, according to the answers they received to a 25th-reunion questionnaire. Comments ranged from flippant to profound:

— "I kept track of my costs [at M.I.T.] one year and I remember \$1,500. Of course I lived in the old barracks and cooked in a lot ... ate day-old bread we got down the street for eight cents a loaf and those dented cans of spaghetti, soups, etc. for half price. Ah, the good old days."

— "I am very confused on whether to send my children to college because of the increasing extent of 'underemployment' as well as the negative ratio of college graduates and need for college trained skills."

— "I dropped out in August, '57. Margaret and I moved into a shanty on a 713-acre worn-out farm that we had bought in 1952 when I was working in the area on a dam-power-house-lock. Didn't think we could last six months but we lived there ten years; then we built a house further back into the woods. We still live *there*. We make our money speculating in land and spend it on conservation."

— "I've made my first \$1,000,000 starting from scratch."

— "My chief concerns are for a return to the values of our forefathers — individual freedom, individual, government and business morality, proportionate burden sharing, economic stability, government responsive to the people, international cooperation, and an independent and strong America."

— "Peanut butter and jelly sandwiches have survived the test of time."

And a pessimist has the solution to our doom: "... Mankind may well kill all life on this earth in the next few decades. There's no way this can be prevented. The only solution is to immediately undertake the construction of a redundant, self-sufficient col-

ony on the moon."

Statistics show changes compared to a similar survey in 1971, according to Messrs. Rubinovitz and Caplan: more of a commitment (81 per cent vs. 69 per cent) to the three major religious faiths; we would more likely recommend business as a field for our kids (22 per cent vs. 6 per cent); more of us are in management (47 per cent vs. 28 per cent); we are making more money (26 per cent earns over \$50,000 vs. 7 per cent, 65 per cent earns over \$30,000 vs. 37 per cent.) □

## Sailing Fund Sails Over Its Goal; New Pavilion Building

The Walter C. Wood ('17) Sailing Pavilion will be dedicated on October 2, the result of a successful fund-raising campaign within the 1975 and 1976 Alumni Funds. Total gifts of \$285,000 from 1,100 alumni were announced at the Technology Day luncheon in June — and the numbers were still growing, up \$500 during the luncheon, said Howard L. Richardson, '31, President of the Alumni Association.

Meanwhile, as the fund reached and even exceeded its goal, pile drivers across Memorial Drive from Walker Memorial were setting new foundations for the Class of 1926 Wing of the new Pavilion. A rebuilt West Wing, representing a major reconstruction of the existing sailing pavilion, will be named for the Class of 1951. Members of both classes have been major contributors to the fund.

The Wood Pavilion will have room for shore school, and there will be locker rooms for men and women. Dock space will be increased by 120 feet, with slips for mooring available for the first time; and there will be boat lifts to move dinghies between dock and storage and to street level. □

## Class of 1931 Unveils Portrait of Margaret H. Compton

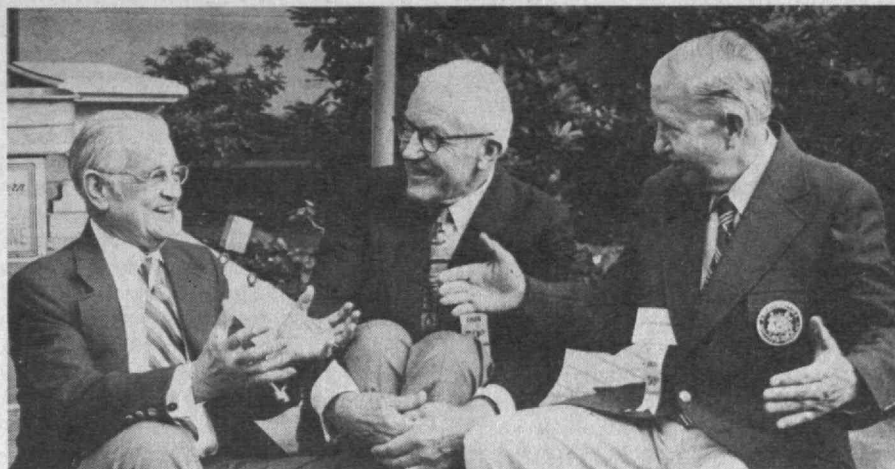
When members of the Class of 1931 gathered in McCormick Hall June 3 to enjoy dinner, dancing, and one another, one of the evening's highlights was the unveiling of a portrait of Margaret Hutchinson Compton, their guest of honor. Mrs. Compton is the widow of Karl Taylor Compton, ninth President of M.I.T., and has been an honorary member of the Class — the first to be graduated under Dr. Compton's tenure — since 1931.

The portrait was the joint project of Jerome B. Wiesner, President of M.I.T., and Mrs. Wiesner, Howard W. Johnson, Chairman of the M.I.T. Corporation, and Mrs. Johnson, and Julius A. Stratton, President Emeritus of the Corporation, and Mrs. Stratton. It was executed by Yousuf Karsh, famous Canadian photographer, and will hang alongside a Karsh portrait of Dr. Compton in the office of the Alumni Association's Executive Vice President. It is the gift of the Class of 1931 to the Institute.

Howard W. Richardson, '31, President of the Class and concluding a year's tenure as President of the Alumni Association, described Mrs. Compton as a "distinguished hostess and an inspiration to many." Mrs. Wiesner recalled the uncertainty of her own first years at M.I.T., and her debt to Mrs. Compton, "who always appeared at just the right time." "She is our first first lady," Mrs. Wiesner added.

Presenting the portrait, Dr. Wiesner remarked that the Comptons provided "a direction and momentum that have made this one of the world's outstanding institutions." He continued, "Hundreds of students in Boston have felt Mrs. Compton's warmth and concern; we're very pleased to say this inadequate thank-you."

Acknowledging the gift, Mrs. Compton noted that "Tech has been an inspiration. To be where knowledge is thrusting forward has been so exciting in my spiritual experience of life that nothing I could give in return would be enough." □



## M.I.T. in the 20s: Self-Reliance Great; Amenities Scarce

What do M.I.T. students of the 1920s remember as the cornerstones of their Institute experience? The need for self-reliance and the freedom to do things on their own, say two of that decade's most distinguished graduates.

Even as a child in a Missouri small town where "they quit math instruction before we got to quadratic equations," says C. Stark Draper, '26, Institute Professor Emeritus whose achievements in navigation and control have been the basis for a major research laboratory named in his honor, "anything I wanted to know I had to figure out for myself. That set the tone for everything in my life since."

James R. Killian, Jr., '26, Honorary Chairman of the Corporation, had the same experience at M.I.T. By today's values, he says the curriculum was "too narrow, vocational, and inflexible. But we were given the freedom to do things on our own."

To report in full the two hours of reminiscences with which Drs. Draper and Killian engaged alumni attending Technology Day is impossible. Here are some highlights of a session celebrating the 50th anniversary of one of M.I.T.'s most illustrious classes:

Dr. Draper remembers M.I.T. as "a very inspiring environment. I learned a mental attitude of using facts as a background to do something *more*, to go further than books and teachers . . . and I was encouraged to work with my hands."

In the 20s he acquired enough money to buy an airplane of his own. And "in those days there were no rules — no checking in and out, no radio. I got myself into odd situations: in clouds, I couldn't see, I didn't know where I was, or what to do next. As a psychologist," he said in jest, "sitting there not seeing, I figured out what was wrong — I was short of information. So I made my own aircraft instruments, at my own expense (no one wanted to invest). I was the designer, lathe operator, mechanic, and pilot. This was unsafe and probably immoral and il-

legal. But I figured if I had an accident I'd get killed and wouldn't have to go through all the legal problems.

"I wanted to make a system that indicated geometry — where you were in respect to the earth — in a self-contained mechanism, like a watch indicates time. What I envisioned has become inertial guidance, now widely used."

Dr. Draper gave the audience a dizzying taste of a pilot's view on a stunt flight. He showed a film ("Airplane in Flight") he took from the back seat of an airplane to demonstrate the maneuvers possible with his instruments. "You've got to do this at high altitude," he explained as the plane looped and turned, the earth and clouds alternating with stomach-boggling frequency, "because at low altitude it doesn't look like anything." During a dive spin, often the result of an accidental stall, the landscape twirled like a pinwheel ("a quick way to get down; watch the field grow in size.")

### James Killian: a Broad View

"There was something bizarre and tragic about the 20s," said Dr. Killian. "Many books have sought to capture its essence: girls with bobbed hair and knee-length skirts, the Transatlantic Flyer, flagpole sitting, the hip-pocket flask (probably filled with alcohol flavored with juniper), raccoon coats, speakeasys, the waltz, the fox trot, drinking wine out of a coffee cup so it wouldn't be detected . . . and the multitude of unrecognized time bombs that went unseen till they exploded at the 20s end."

"I came to M.I.T. in the fall of 1923. The physical environment was grim: pebbles in Great Court, amenities rare, athletic facilities scarce. . . . But bleakness was not the whole story," he added. "That Stark Draper could have done what he did is evidence — there was an extraordinary array of able people. Remember that in 1919, Vannevar Bush and Norbert Wiener were appointed; in '26, Stark Draper, all to become world famous.

"And a large number of alumni (especially from the class of '26) remained at M.I.T. (Some say students from '23 and '26 felt that M.I.T. so much needed improvement, they stayed around to help.)

"We didn't have the problem of hostility



and violent protest," said Dr. Killian. But Tech students weren't devoid of mischief: they welded shut the gates of Harvard yard; they welded a train to the tracks. And one day a Model T Ford appeared in a lab basement. "No one could figure out how it got there unless it was disassembled," Dr. Killian remembered.

He, too, concluded with a film — of "a group of overworked, underfed Tech students." The audience loved it. — M.L.

## Aero and Astro: Alumni Sing Its Praises

If aeronautics and astronautics has a problem at M.I.T. today, it's simply this: not enough students. Too few undergraduates realize the many opportunities it offers.

Some 100 alumni of the Department attending a "mini-reunion" on June 4 heard with dismay and astonishment that only 12 bachelor's degrees — the smallest group in "many years," said Rene H. Miller, Head of the Department — were given in aeronautics and astronautics at the Commencement Exercises a week before.

But the undergraduates who decided aero-and-astro was a declining field were wrong, and their successors are beginning to discover the mistake. Perhaps 40 sophomores will sign up next fall, thinks Professor Jack L. Kerrebrock. And if you extrapolate growth at that rate into the future, "we'll take over the Institute in 2075."

Good reason for the rebirth of interest. The Department has "one of the best employment records of any at M.I.T.," said Professor Miller. And there's a "great need for young people — a wonderful future in the field."

### The Dominance of Truth

If, as Professor Miller thinks, aero-and-astro's biggest problem is to toot its own horn, some undergraduates should have been on hand to hear the alumni praise their profession — and the start they received in it at the Institute.

Aeronautics is a profession in which "truth is dominant," said Teddy F. Walkowicz, '41. "If you build an airplane with a little untruth in it, you find out soon enough — and the hard way." The profession can claim some unequalled accomplishments, said Mr. Walkowicz:

— We've "saved the world from the U.S.S.R."

— "We've taken people to the moon and back."

— "We've given the whole world the greatest transportation system in the history of the world."

"Our profession and the graduates of this institution have accomplished more for the preservation of our society and its freedom and ideals than any other group of people in the world, and don't forget it!"

The average age of professional engineers now practicing in aeronautics and astronautics is 45 to 50, said J. Russell Clark, '29, and there's a message in that fact: a brisk demand for new, young engineers cannot be far in the future.

Ira H. Abbott, '29, thinks the demand is overdue. Forty-five is "too old," he said. "Old" people know "too many things that can't be done"; there's a danger "for any company that lets its engineers on the research side average over 40."

### Don't Forget to Build an Airplane

How does the Department of Aeronautics and Astronautics teach today?

Professor Kerrebrock described a new experiment in "unified engineering" — teach all the basic concepts, principles, and methods of engineering in a single, coordinated two-semester subject ("24 hours of hard work" per term): fluid mechanics; dynamics, statics, and mechanics; structures; thermodynamics and heat transfer; control; even systems and simulation. When the year is over, said Professor Kerrebrock, "the students are exhausted and so are the faculty." But "there's a lot of close contact," the students learn a lot, and they like it.

A new curriculum called avionics combines work in aero-and-astro with electrical engineering, said Professor Walter M. Hollister, '53. He hopes there will soon be a new "double major" in that field leading to a bachelor's degree granted jointly by the two departments.

A man-powered airplane? The ill-fated effort of two years ago to build "Burd I" has now been succeeded by a student team working on "Burd II." It's a serious engineering project, said Professor James W. Mar, '41 — a solid learning experience. (It's also convenient, he admitted, that a co-ed on the project has a boy-friend who is an amateur bicycle racer.)

Learn aerodynamics by doing it — and watching it, said Professor Hollister, who showed how undergraduates used tape-recorded television segments to correlate wind tunnel results with flight test results. How to "move out of the laboratory into the real world," he said.

"But don't forget to teach them how to build an airplane," advised an alumnus as the "mini-reunion" bull session ended. □

## Energy: Relax and Let the Market Work

There is nothing scarce about energy today. "Crisis" and "revolution" are hardly the words to describe our present problem — or perhaps even mankind's future one.

Why, then, the rising prices of our oil, gas, and electricity? Because, says Morris A. Adelman, Professor of Economics, higher fuel prices expected in the future are an incentive to producers to withhold fuel from today's market. In that sense, he said, present prices forecast what today's fuel suppliers expect of tomorrow's prices, and so "a future scarcity is pushed into the present."

This prediction of future scarcity in contrast to present scarcity is the difference between fuel prices in the 1960s and the 1970s, Professor Adelman told a Technology Day audience on June 4.

### Imperfections and Mistakes

None of the members of the M.I.T. Energy Laboratory speaking on "The Energy Revolution" on Technology Day could argue with the assumption of future fossil fuel scarcity in relation to growing energy demand. Professor Jean F. Louis proposed modest increases in the efficiency of electricity generation from fossil fuels during the next decade, the result of using new high-temperature materials, "topping cycles" utilizing high-temperature technology, and new "fluidized-bed" combustion systems. But the increases in efficiency will be of the order of a few per cent, hardly enough to keep abreast of rising energy demand.

Progress toward fusion is steady, and the gap between the state of the art and the theoretical goal is narrowing. But that gap is still very wide, and it represents fundamental science and — especially — very exotic technology. Successful Alcator experiments in the M.I.T. Francis Bitter National Magnet Laboratory (see *May*, pp. 22-23) encourage Ronald R. Parker, Sc.D. '67, and his associates in the Laboratory to proceed with a new and larger experiment. But no one is ready to promise that fusion power can be achieved, or when. Will we be able to afford it, if we can reach the goal? Professor Sidney S. Alexander of the Sloan School of Management has no doubt that the market system will bring supply and demand together in the year 2100 — just as it does today.

But the market system is imperfect when it deals with energy, said Professor Adelman. Three reasons:

— Suppliers and consumers are not all-seeing; they make mistakes.

— The extent to which coming events should cast their shadows on present prices can never be surely known; especially because predictions of future technology — such as fusion — are far from accurate.

— Government interferes with the market system through production and/or price controls — "a displacement which usually results in waste," said Professor Adelman.

Two examples of the latter were cited during an afternoon energy policy seminar:

1. Extensive government commitments to research, development, and pilot plants for synthetic fuels (gas or liquid) from coal ignore the "free market" constraints on costs. Almost surely, said Lawrence H. Linden, a graduate student in mechanical engineering, such synthetic fuels will be more costly than the fossil fuels they replace. The free market — the breeding ground of truly fruitful technology, said an alumnus in his audience — will never have a chance to exercise its wisdom.

2. Present government regulation of natural gas keeps prices low outside of producing states and assures priority supplies to households. Industry's response is to abandon its plants in non-producing states and move to places where higher-priced local gas is assured; extra costs are passed on to consumers, says Professor Jerry A. Hausman. (But government regulation is not necessarily counterproductive; consider the price controls on petroleum, said Professor Hausman: the price of newly-discovered oil is set at 2.5 times that of "old" oil, and this creates powerful and useful incentives to discover new supplies and extract more "new" oil from old fields.) □

## What's So Special About Middle Age?

What's it like to be middle-aged — say 45 to 50?

Instead of asking the Class of 1946, Professor Edgar H. Schein of the Sloan School of Management had the temerity to tell them. "Special tasks face people in mid-life," he said, and he proposed that "if you recognize these, perhaps you can cope better . . . because the essence of coping is to recognize options, to concentrate action on the things you can do something about instead of concentrating frustrations on the things you can't."

Three basic sets of concerns interact as people live, Professor Schein told members of the Class at a reunion seminar on June 5: "work," "family," and "self." No one of these can be studied except in the context of the others, and no one should attempt to make important personal decisions on the basis of only one of these three elements.

Professor Schein and his colleagues in the Sloan School's Organization Studies Group have identified a set of five "career an-

chors" — basic personal characteristics which tend to be determinants of career choices throughout life.

Some people, for example, are primarily interested in technical competence; they simply want to be good in some important specialty. Other people are "born managers": they want management responsibility and authority as soon as possible and as much as possible; the "managerial jungle" is their thing. In a third category are security-oriented people content to let others evaluate their strengths and direct their talents. People who become entrepreneurs are in a fourth group; their principal characteristic is "creativity," and they are constantly "driven by the need to do something new and different." Finally there are "company drop-outs," people who find they want to lead their lives on their terms; and they tend to become consultants and professors.

Which group is each of you in? Professor Schein asked members of the Class of 1946. Before people start rearranging their lives, he said, they'd better answer that question; it's "important for people to see themselves as they really are," to discover their own traits and characteristics in order to avoid bad career decisions.

This is an era of rapid change, a time of new freedom for many people in many ways, said a member of the Class. What about all these exotic new careers we read about, and dream about? The striking thing which emerges from studies by Professor Schein and his colleagues, he said, is the consistency and stability of most careers. People who start focusing on technical competence usually continue to do so; if they enter management, for example, they do so reluctantly and in assignments of limited scope. Though some career changes seem to be radical and even exotic, there often are fundamental elements of consistency.

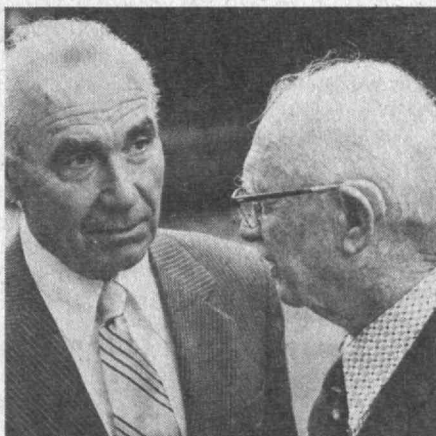
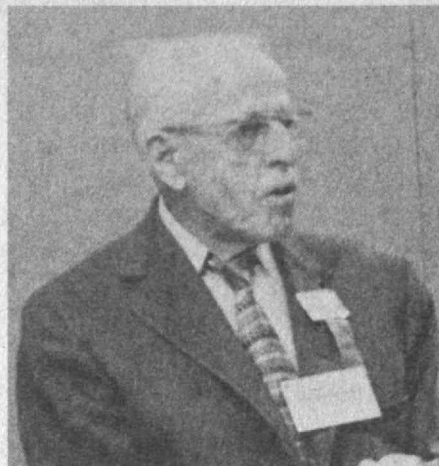
#### The Time When "Time Is Running Out"

But such questions of career cannot be considered in a vacuum; they interact with "family" and "self," and solutions to the problems of middle age, however you see them, must satisfy all three kinds of concerns. Professor Schein gave a long list of specifics which may be relevant: the pattern of your spouse's career; the number, ages, and needs of your children; you and your family's health; your role as parents, grandparents, or providers for your parents; your sense of your own career satisfaction and your wishes for retirement . . .

Perhaps the most crucial — and the most subjective, and hence most difficult to analyze — of the questions that come to bear on people as they reach middle age is the growing realization that "time is running out," that therefore "the die is cast." Because one's abilities and energy are not what they used to be, one may suddenly realize at this period in life that one's career and personal development have gone about

as far as they will go. There follows a final — and sometimes depressing — assessment of present realities in terms of former dreams, and so middle age becomes a time of fundamental change in attitudes — and sometimes in modes of life, as well.

"Somewhere in mid-life we stop blaming our parents for what we are," Professor Schein told the Class. There may be a set of entirely new concerns for self-development, a new relationship with one's spouse, a "new sense of responsibility for one's life and one's uniqueness." □



*Reunion memories (top to bottom): John J. Nolan, '03, the oldest graduate at the Technology Day luncheon. The Class of 1921 touring Boston Harbor on the "Bay State." Ross H. Smith, Director of Athletics, with Jasper B. Carr, '16 (right). An off-year "mini-reunion" of the Class of 1924. (Photos: John I. Mattill, Calvin Campbell, and Darrell J. King, '72)*

## In This Section

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Awards, appointments, and elections are the special business of spring ... **page 96**

## Under the Dome: the General Assembly, Athletics, and News as the Term Ends

### General Assembly Coming Back to Life?

An abortive effort to rejuvenate the General Assembly of the Undergraduate Association — after six years of inactivity — following new U.A. elections in the spring left student government as important in 1975-76 as it has been in the several previous years.

The General Assembly includes about 100 students, one representative from each fraternity and several — allotted by population — from the dormitories. Charles Denk, '79, said the meeting was "disappointing — the potential seems to be severely limited by the people involved and their behavior; it took two hours to run through minimal business."

But Mr. Denk admitted "you can't really tell about future meetings from this one." And the new President of the Undergraduate Association, Philip C. Moore, '77, listed a series of issues which he hoped the U.A. could deal with — "students' ability to affect the quality of the living environment," budget priorities, minority admissions, tuition, housing policy. "We feel that the only way students are going to have an influence on the way policies are made — or change the situation so that the student body does get to participate significantly in decisions on university policy — is through organizing and voicing common concerns together. We have to make up our own minds about how we're affected by Institute policies and how we want to change them," wrote Mr. Moore in the *U.A. News* insert for *Thursday*.

### Woman Heads the Athletes

Wendy C. Irving, '77, is President of the Athletic Association for 1976-77 — the first woman in M.I.T. history to be elected to this key position in M.I.T.'s unique "maximum participation" athletic program.

One of her male competitors for the job said he didn't mind losing to a person he knew would do a good job. That pleased Wendy — it meant, she said, that she had "gotten her ideas across" in her election

speech. She called for better communication among the various groups using the hard-pressed athletic facilities, revised athletic programs which are more nearly in step with demand, and greater student input into planning and use of the proposed \$6.2-million athletic and special events center.

Ms. Irving says her election proves to her that these are "ideas that need implementing."

### N.S.F. Fellows Choose M.I.T.

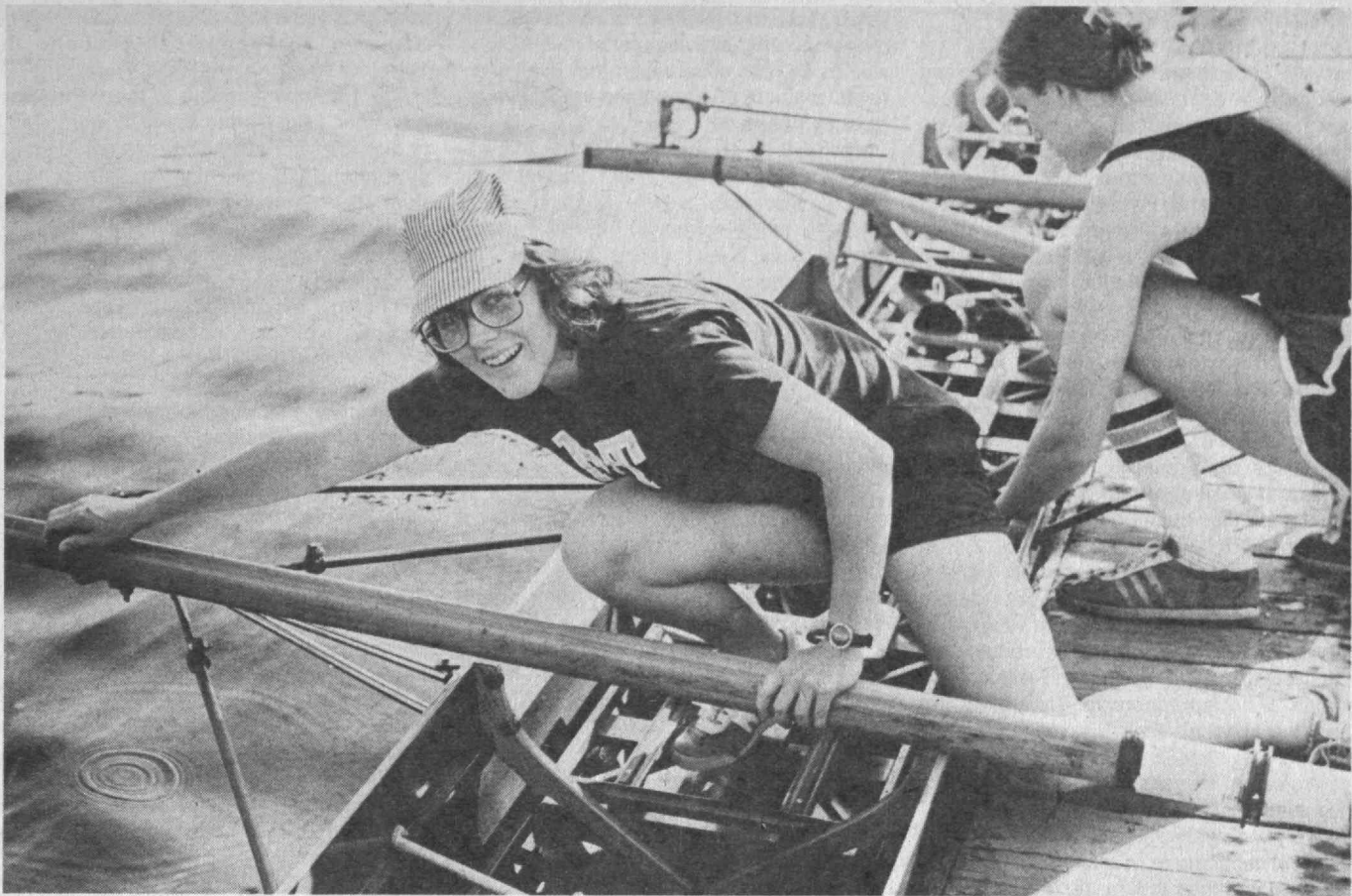
For next year, the National Science Foundation has awarded 550 fellowships to first- and second-year graduate students and 10 per cent of these N.S.F. fellows — they have their choice of schools across the nation at which to study — will be at M.I.T. It's a high tribute to the Institute's Graduate School, thinks Dean Kenneth R. Wadleigh, '43.

### Prize for "Capacity Building"

Seven students and alumni of the Department of Urban Studies and Planning — they are the authors of a paper describing the planning study for Rockport, Mass., completed two years ago — have received the Ted Aschman Memorial Prize of the American Society of Planning Officials. Their paper was about "capacity building" — a concept for teaching citizens planning principles so that they can take a greater role in local affairs.

### Community Service Fund Expects \$30,000

Gregory Smith, '30, Co-Chairman of the Trustees of the Community Service Fund, says its income from gifts will be about \$30,000 in 1976-77, and has now allocated some \$28,000 to M.I.T.-related community activities. New beneficiaries this year will include Access (formerly the Cambridge Hotline), the Adult Literacy Program, the M.I.T. Scouting Adviser Program, and a student project which is part of the Chinese Community Big Sister-Big Brother Program.



Wendy C. Irving, '77, is the first woman ever elected President of the M.I.T. Athletic Association — the student organization which shares with the Athletic Department faculty

the management of M.I.T.'s big sports program. Ms. Irving was Captain of the women's swim team last year (and she will be again next year), and she is a member of

the women's crew where — despite the handicap of being only 5'5" — she pulls a strong bow oar.

Continuing funding will be supplied by C.S.F. to the Boston Chinese Community Youth Program, WTBS Community Broadcasting, the Cambridge Community Center, the Group School, Just-a-Start Corp., Tutoring Plus, and M.I.T. Urban Action. M.I.T. students and staff act as volunteers in all these community agencies and it is primarily for support of their work that C.S.F. funds are granted. The proposals this year came to \$60,000 — twice the amount available for allocation.

### "Treat the Women Like Any Other Students"

"Professional women are normal; we want the joys of life like anybody else," says Mildred S. Dresselhaus, Abby Rockefeller Mauze Professor of Electrical Engineering, in an article on women in engineering in *Cosmopolitan* magazine.

It's the men who have trouble, not the women, said Professor Dresselhaus. "Male faculty members are just beginning to see women in their classes, and they're still not sure what to do with them, so they come to me for advice." Her answer: "Relax and treat the women like any other students."

Ms. Dresselhaus cites herself as an

example of the compatibility of family life and professional career. "I consider my home a career, too. But I never took any time off to have the kids. They just sort of worked into my schedule." She adds, "I couldn't have done it without a husband who believed in me. He's unusual for men of his generation," she told *Cosmopolitan*; but "I think young men today will be much better in that respect — they don't expect women to wait on them."

### Funding the Health Sciences

The Health Sciences Fund, an independent philanthropy established to support programs at M.I.T., Harvard Medical School, and the School's teaching hospitals which are collaborating with M.I.T. on teaching and research, will make grants of at least \$500,000 in 1976.

Fellowships for medical students completing Ph.D. theses in the joint Harvard-M.I.T. Program in Health Science and Technology have been added to the Fund's earlier funding projects, which include doctoral fellowships to support medical students and research grants in the life sciences. Irwin W. Sizer, Dean Emeritus of the M.I.T. Graduate School, is President of the Fund. □

## Learning Invention: Study Everything and "Soak in a Tub"

Can innovation be taught, like physics and chemistry, statics and dynamics?

The answer, says Professor Yao T. Li, Sc.D. '39, Professor of Aeronautics and Astronautics who directs the Innovation Center, is both yes and no.

Innovation is like love, says Professor Li — a basic instinct of mankind, to be learned more by example and experiment than in the abstract. But there's evidence that Professor Li's method in the Innovation Center — teaching "by showing them how to do it," he told members of the Alumni Advisory Council this spring — works well enough. A series of student inventions, some of which have achieved significant commercial successes, was proof to most alumni in Professor Li's audience. "It's the first time I've heard M.I.T. have its pulse on what is going on in the real world," said one member of the Alumni Advisory Council during the discussion period.

## "Parameter Analysis" and Soaking in a Tub

An M.I.T. undergraduate who wants to get into innovation usually starts by signing up for 16.671 — Invention: "Process of invention discussed. Invention by analogy. Analysis of invention feasibility. Case study of invention and inventor..." The next stage is 16.672 — Entrepreneurship: "Lectures on concept evaluation, patents, licensing, contract negotiation, organization, marketing, business planning, financing, accounting, and small-business management..."

After that, it's into the laboratories — one in invention, the other in entrepreneurship. The problem in the Invention Laboratory is to reduce some specific invention to practice, in the Entrepreneurship Laboratory to work out "the marketing phase of product development," says Professor Li.

The whole point, Professor Li told the Alumni Advisory Council, is "to put students in an innovative framework" in which they and their colleagues see how products are devised and then learn the practical elements of entrepreneurship — planning, designing, building, licensing, marketing, and selling.

Professor Li calls his methodology for teaching innovation "parameter analysis" — an effort systematically to review key issues of technology, demand, and marketability, the things that make "the difference between success and failure," said Professor Li. But he admitted that an important part of the process, in addition to formal "parameter analysis," takes place when you "go home and soak in your tub."

## Going Into Business as a Student

Does it work?

Philip J. Doucet, '74, took his first course in the Innovation Center three years ago and began almost at once to "nurture a basic desire to be an entrepreneur." When the "energy crisis" came along he decided there was a market for an automatic control system for heating and air conditioning that would improve efficiency and save energy. A year ago he finished a prototype control unit suitable for a small office or industrial building which has been working satisfactorily ever since. Now he and three other principals have incorporated Computer Controls Co. to manufacture and sell control systems (fire and theft alarm circuits are built in) and the programs by which they operate, and the company's first sales meeting was scheduled for June.

Mr. Doucet is still a part-time student — working for his Master's degree — in the Sloan School of Management. He told the alumni he thinks "it's a great time to go into business for myself." His practical business experience, he says, makes a big difference in how he understands his courses in management.

## Success? Sometimes; Future? Uncertain

The Innovation Center's most conspicuous success to date is in electronic games,

where the experience demonstrates some of the opportunistic aspects of invention as well as Dr. Li's observation that M.I.T. students are both energetic and innovative almost by nature.

Intrigued by an article about the Innovation Center in the *Wall Street Journal* more than a year ago, a New England small-company (not electronics) executive asked Professor Li if any of his students had thought about simple electronic games which could be inexpensive add-ons for home television receivers. No one had; but in three months a team of five students had devised a kind of electronic ping-pong. It was licensed to the executive's company in July, 1975, and production has now reached more than 1 million units.

From Klein Corp., another outgrowth of the Innovation Center, you can now buy a large-diameter (1.5-inch) aluminum competition bicycle frame with the highest stiffness-to-weight ratio of any frame on the market. ("When pedalling force is applied to a bicycle," says Klein Corp.'s literature, "part of it is wasted in deflecting the frame. The harder one pedals, the greater is this loss. This energy is not returned to the power train when the frame springs back; it is returned to the rider's legs. Unfortunately, muscles cannot reabsorb energy, and the energy is lost.")

Will the Innovation Center succeed?

Student enrollment has been increasing dramatically, tripling between 1973-74 and 1974-75 and increasing by another 50 per cent between last year and this; there were 111 student participants in the fall term of 1975-76.

The Center is now funded by a \$100,000 National Science Foundation grant which will be exhausted — at the present rate of expenditures — in the summer of 1977. It shares with inventors the royalties on successful innovations, and Dr. Li hopes this source of income may eventually make the Center self-supporting. But he fears that both financing and space for its growing activities are likely to be serious problems before then. □

## Inertial Guidance for Taiwan?

Fifteen advanced engineering students from Taiwan have been on the M.I.T. campus since January, 1975, studying electronics and inertial guidance under a contract between M.I.T. and the National Taiwan University. Their presence, largely unknown in the M.I.T. community until early in 1976, precipitated student and faculty concern this spring and eventually a student-faculty committee investigation, and as the term ended President Jerome B. Wiesner said the program planned for the Taiwan students is to be changed "to

strongly emphasize capabilities for industrial and commercial applications in Taiwan."

The 15 students came to the Center for Advanced Engineering Study to learn electronics and high-technology in a non-degree program. Upon returning to Taiwan they were to become the nucleus of an entrepreneurial group developing high-technology export industries to bolster Taiwan's economy. To give them "hands-on" high-technology experience, the Taiwan students were to "carry out a prototypical inertial navigation system as a laboratory project."

Originally that inertial navigation work was to be carried out at the Draper Laboratory, where inertial systems for both military and space applications have been a specialty for over two decades. But the State Department's Munitions Control Board intervened: the Draper Laboratory should not direct the "hands-on" project for the Taiwanese. So that aspect of the program, revised and reduced, was transferred to M.I.T. laboratories.

Then, just as students and faculty were becoming aware of the project early this spring, came the challenge from the Student Action Coordinating Committee — the same group (at least in name) which six years ago spearheaded the attack on the Draper Laboratory for its role in classified military research: of all the high-technology subjects appropriate to the world market which Taiwan proposed to enter, why choose inertial guidance for special emphasis? Or was the program a "front" under which M.I.T. was providing Taiwan with sophisticated new technology for targeting missiles and warheads — and thus escalating the arms race?

After an investigation requested by President Wiesner, an *ad hoc* student-faculty Committee on International Institutional Commitments reported with a double-negative: it could not find "convincing evidence that the primary objective of the training . . . is other than military."

But Dr. Wiesner and Paul E. Gray, '54, Chancellor, drawing on an intensive investigation by the administration, were not ready to agree: "We cannot come to the conclusion that military purposes were the objective of this program." But they admitted to questions about the program's appropriateness, and they said its steering committee was being asked "to recast the program to strongly emphasize the objective of developing capabilities for industrial and commercial applications in Taiwan."

The spring-long debate, though it involved only a small proportion of students and faculty, brought back to M.I.T.'s corridors the vernacular of campus activism in the 1960s: "If the deal turns out to be military, would you approve it or not?" Thomas F. Jones, Jr., Sc.D. '52, Vice President for Research, was asked at a rally. "Are you in favor of nuclear proliferation?" Dr. Wiesner was asked. (His answer: "I fought to stop it when you were in diapers.") □

## Waste Treatment By Electrons

No breaking of champagne or christening with wastewater marked the dedication of the experimental electron treatment facility at Boston's Deer Island Wastewater Treatment Plant this May. Instead, its developers (and particularly, Professor John Trump and the M.I.T. High Voltage Research Laboratory) gathered to show off their new baby to state and local officials, and to the National Science Foundation and Sea Grant representatives who financed and encouraged the project.

Professor Trump, who with his associates at the M.I.T. laboratory was a pioneer in the use of high-energy electrons and x-rays for medical therapy and for the sterilization of surgical materials, explained his hopes for this new method of waste treatment.

Since the days when raw sewage was poured directly into streams and waterways, cities have had to invent ever more sophisticated methods of treating waste. Awareness of the viruses and microorganisms which luxuriate in sludge has recently proved previous methods of treating sewage inadequate. Most waste treatment facilities, Deer Island among them, concentrate the sewage into sludge by removing much of the water, and then treat the sludge anaerobically, encouraging microorganisms to eat as much as they can of the waste. The digested sludge remains a problem, as Environmental Protection Agency regulations forbid its effluence into the ocean, and the sheer amounts of sludge produced in the U.S. (10 million tons a year) overwhelm other disposal methods.

Enter Dr. Trump. "The thicker the sludge, the better we and our electrons like it," he says.

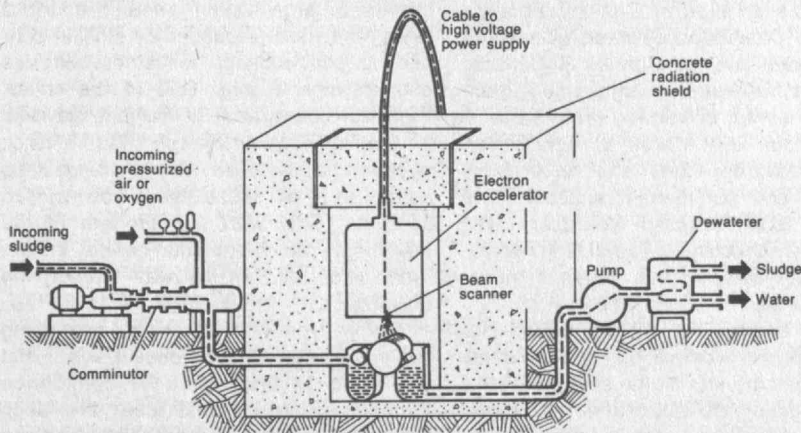
In the experimental facility, eager electrons are revved up in an electron accelerator, and then zapped machine-gun-style at a thin, wide stream of slurry which passes steadily under the electron beam. The tiny electron bullets, 300 million billion

of them, which scan the sludge stream 400 times each second, destroy the bacteria and viruses in the slurry. The disinfected slurry can then be used for fertilizer or landfill. "You can see luminosity where the electrons hit the sludge," says Dr. Trump. There is absolutely no possibility of radioactive contamination of the sludge by this method. "As the sludge absorbs this special kind of electrical energy, its temperature is raised 2°C." This is much less energy than it takes to pasteurize milk, he says.

It is even more efficient to homogenize the sludge before irradiating it. "This shakes up the colonies of bacteria and virus before irradiation, and weakens them," explains Anthony J. Sinskey, M.I.T. Professor of Microbiology, also involved in the project. Luckily, he says, the coliforms and disease-carrying bacteria are the most sensitive of all the bacteria the scientists are after. His tests have uncovered no signs of mutations or developing resistance to irradiation, he says. That they would spawn "the garbage heap that ate Boston" is an impossibility.

One virus type may survive this treatment better says T. G. Metcalf, Professor of Virology at the University of New Hampshire. That is the virus that causes hepatitis, called Hepatitis A. The problem with this strain is its size, he says. "The smaller the virus, the smaller the target, and the smaller the nucleic acid core the electron must hit."

The immediate purpose of the experimental facility, which can treat a third of Deer Island's daily 300,000-gallon sludge throughput, is to study the disinfection efficacy of this new treatment process and the engineering practicality of the system. "If it is successful, the irradiation of municipal sludge by high energy electrons may prove to be the most important new treatment method that has emerged in the last half-century," says Dr. Trump. — S.J.N.



Sludge entering the test treatment facility at Deer Island is passed under a sterilizing electronic beam.

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# Students

## Once Bloodthirsty Architecture Reviews Have Changed: Quiches, Cheesecakes, and One-to-One Talk

Semester end. For first-year students in architecture, it's review time. Older students say it was to be dreaded: the scene was like a courtroom. One weak-kneed victim "defended" his work — facing the class plus 25 critics (called jurors), all front-row prosecutors outdoing themselves (some students felt) in often sadistic criticism. "Reviews used to be bloodthirsty," explains Professor Jan Wampler. "Having one student at a time defend his work was not an educational experience." So his class review is different.

Quiches, cheesecakes, huge salads, breads, coffee cakes, wine; a feast on a makeshift table amid architecture studio clutter transformed the room — and the atmosphere — from what might have been solemn and ominous to that of a party. And after a fabulous lunch, critics were scheduled to talk on a one-to-one (or two-to-one) basis with students for an allotted time, then to change partners. "Something valuable can come out of a one-to-one discussion," says Professor Wampler, "and this takes the tension out of the reviews."

### Design for People

The focus of the Level I Architectural Design project was an area of Cambridgeport (a section of Cambridge between Massachusetts Avenue and the Charles River, near M.I.T.) that has a strong neighborhood identity and some collective activities. A neighborhood center was to include cultural, health, day care and recreational facilities, and commercial spaces. "The problem," said Professor Wampler, "was fitting different activities like elderly recreation and day-care together. You gain something from that."

How to begin? "At first we divided into groups. Some worked out a sun study (where does the sun hit the site?), others a traffic study; others talked to neighborhood people to get a sense of the community and its needs," explained Mary Griffin, graduate student. "Professor Wampler wants stu-

dents designing for actual people." (Large photos of Cambridgeport residents hung on the studio walls — a constant reminder of those who would use the proposed building.) She went on: "Jan believes a physical framework should allow people to come in and take possession of the space. My masonry walls (she pointed to her model) show what people who come into the building might do — they can add lofts or low walls."

Students had sketched plans for a community center, enlarged one section to analyze in detail how the space would be used, built small models, and one large final model. Their original concept went through many evolutions.

To Ms. Griffin, the model work was the most important step. "If I can stay loose enough from my original sketch, I can use the opportunity to think on a three-dimensional level," she said. "There are many little decisions that can be made at that stage."

### "Remember Your Central Theme"

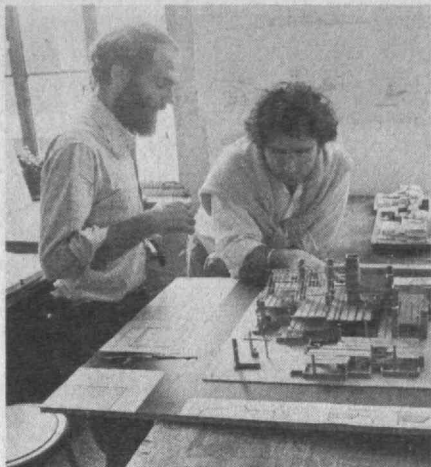
Bill Rawn's solution to the community center was to envision the public part of the building as a large "main street," under a skylight. It was surrounded by smaller connecting constructions for other activities and commercial use. One of the critics, Professor John Ziesel of Harvard, advised:

"Start off with an overall image. Test it against what you know. As you change it, be careful to retain those things you want to build on. Stay with the strength of the statement; remember your central theme. Think your idea all the way through the building."

"Before you start changing something into some other metamorphosis, keep what you liked at first. Lack of confidence prompts losing the first idea; I've seen people go back to a discarded drawing and pull out a first solution — still the best — but lost amid many changes. You have to have



*Students of Professor Jan Wampler (above) in Level I Architectural Design had no sooner finished a luncheon buffet in the studio when semester-end critiques began. On the opposite page, left, graduate student Peter Polhemus (left) talks with critic Robert Manoff, instructor and Ph.D. candidate in architecture; graduate student Mary Griffin discusses her project with critic John G. Bemis, M. Arch, '75. (Photos: Roger N. Goldstein, '74)*



faith in your first inspiration."

Round robin critiques continued. As Professor Ziesel was whisked to another student, Kevin Lynch, M.I.T. Professor of Urban Planning, appeared. He saw Bill's project from another angle: the complexity of the design (especially its many different floor levels) would drive construction costs up — and flexibility down. "Suppose Reagan gets in," he said, "and there's no more day care center funds — what happens to that space?" Bill agreed that he was so intent on breaking up the simple spaces that they became too complicated. "But how do you design in an ability to change?" he asked. The answer: keep modular spans, floor levels even, and room sizes that work well for many uses. "The M.I.T. main building was designed for flexibility — and it works, primarily because of general floor levels."

A simple space can be given the feeling of complexity by the smaller elements (benches, chairs), places to lean against (a wall, a mailbox), places where people can sit that are protected in back, in sunlight, and right up against the action. "Look at Boston's Government Center," Professor Lynch suggested — "all those big benches under the trees. But people choose to sit on the edge of the subway entrance — it's in the sun, and they can watch people. It works every time."

Professor Lynch liked the idea of the central "main street." He suggested interest generators on each end, to keep people moving through. And he offered more criticism: the skylight would put a load on the air conditioning in hot weather, tend to leak in the rain, and let in cold in winter. The day care center would create a problem: located on a private residential street, a lot of people would resent the noise.

The party/review was coming to an end. Small knots of people surrounding a model here and there could still be heard: "A one-and-one-half year old can wander out that door and toddle right away . . . Dropping a commercial establishment back from the street makes a huge difference in its visibility — and business. . . . Roof and deck balconies increase the risk of people breaking in or getting hurt — it's better to put nooks and crannies inside . . ." — *M.L.*

## Classroom Drama: Nuclear Power Plant — Yes or No?

For citizens of Montague, Mass., and western Massachusetts, the proposed establishment of a nuclear power plant there has great advantages — and potential hazards. For Professor Michael Baram's class in environmental law, this real situation became a classroom drama: weekly three-hour hearings to decide whether the plant proposal should be approved were held this spring term before a simulated Massachusetts Energy Facilities Siting Council. (The real council must approve all energy related facilities — subject to Federal approval of the Montague site and plant design.) The case is imminent, but has not yet been heard — and the Nuclear Energy Regulatory Commission in Washington, which has authority to grant construction and operating permits, has also not made a decision. So the case was ripe for classroom use; students used the extensive materials and studies generated by state, federal and regional agencies.

Three student groups were involved — those representing the utility that wished to build the plant, intervenors who opposed it, and the council who at the end of the hearings had to reach a decision. Factual presentations included forceful harangues and hesitant sidestepping, from propositions on safety by intervenors, to faltering promises of solutions by utilities representatives. Coolly observing the presentations, the five-member council came to their conclusion: the intervenors' request for a delay would be granted, not because of safety, but because a convincing case of need had not been made. The proposal was remanded to the utility for further information. "A responsible decision," said a pleased Professor Baram.

How did students feel about the class experience?

"Each council member had a different perspective," said Ann Hoffman, a graduate student at Harvard who served as council chairwoman. "But that is real life, and it was

interesting to me because there were no answers, and a great amount of uncertainty. Our task was to minimize this uncertainty — and to make a collective decision." The intervenors, she felt, concentrated on generating a fog of emotionality and fear of uncertainty, without coming to grips with the realities of need. The siting council had to center on the factual and procedural parts of the debate. "I gained something from questioning and responding to other class members in front of the group," she added.

Was the debate genuine? "I think people believed their positions — their hearts were in it; they weren't playing a role," said Nancy Stack, a Harvard graduate student.

"The debate required more work than the normal assignment — it had to make sense and had to be defensible," said Stuart Freudberg, an M.I.T. graduate student in civil engineering. "But once the position paper was written, it was fun — and it gave everyone a valuable opportunity to speak representing a group, which you don't usually get in a classroom situation."

Why the classroom simulation? "M.I.T. is highly theoretical," said teaching assistant William Lee. "There is a move in many departments to involve students in real-life policy. And there is something to be learned by working in a group. They had to meet and divide up jobs; the siting council had to arrive at an integrated opinion."

Next year Professor Baram intends to repeat his experiment, allowing time for more extensive preparation and, perhaps, cross-examination. "Simulated legal and administrative proceedings such as this," he explains, "affords students the opportunity to grapple with a problem of the type confronting government decision-makers — a problem involving technical and analytical uncertainties and diverse values and assumptions. The process helps to develop objectivity and analytical skills, an appreciation for rational approaches and for real concerns of the public."

Arnold Wallenstein, an attorney with the New England Regional Commission, worked closely with Professor Baram and William Lee in preparing the materials and format for the hearings, and "deserves much of the credit," according to Professor Baram. — *M.L.*

## Solar Energy for White Mountain Huts

The typical forecast is rain, overcast and scattered clouds — far from ideal weather conditions for a solar water heater. But George T. Tremblay, '75, didn't let that discourage him. With support from M.I.T.'s Undergraduate Research Opportunities Program during his senior year in Architecture, he developed a solar hot water heater for use in the Appalachian Mountain Club hut system in the White Mountains of New England.

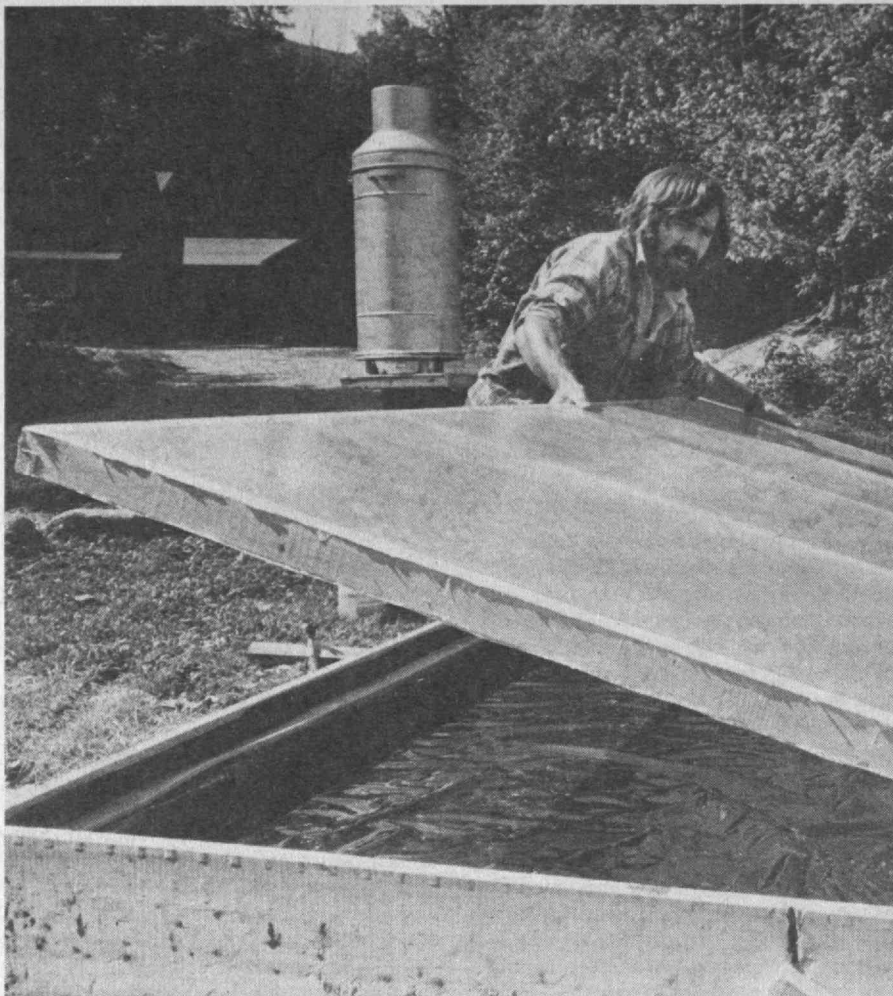
These eight unique "huts" (trail-side accommodations whose capacities range from 36 to 90) provide food and lodging for thousands during summer months. So they need energy for cooking, hot water, lighting, refrigeration, and water pumping. Power for these operations comes from bottled propane — periodically airlifted up the hills and over the valleys at great expense.

Now, (after a prototype designed by Tremblay passed its test last summer), a complete solar water heater system is being installed at Zealand Falls Hut this summer. It should be big enough to supply the Hut with "all its hot water needs," writes Tremblay in the May, 1976, issue of *Appalachia*. Excerpts:

"The arrangement . . . at Zealand Falls Hut . . . will consist of three 4 ft. by 8 ft. solar collector panels. These panels will be erected horizontally for summer use only. Water taken from nearby Whitewall Brook at approximately 45°F. is introduced to the panel in the morning and is heated through the course of the day in the insulated, plastic-covered collectors. Upon reaching the 'design temperature,' the water will automatically flow out of the collector into the Hut's insulated storage tank to await use. The collector will then refill itself and repeat the cycle as many times as the day will permit. Heat will be gained even on mildly overcast days due to the nature of the flatplate collector. One hundred gallons of water can be heated on the average summer day, and three to five days' supply of water can be stored in an insulated tank for use on overcast days. The present propane system will remain as an auxiliary and experiments will be conducted to integrate the two systems.

"This process will net a decrease of approximately 25 to 30 per cent in propane consumption — a savings of over \$200 per year in propane and transport costs for Zealand Falls Hut alone. At this rate the solar installation will effectively pay for its capital cost in under three years, based on 1974 fuel prices. If installed at other suitable huts in the system, considerable savings could be realized."

Mr. Tremblay gives solar energy his firm support: "The power from the sun is ours for the taking," he says. — M.L.



*Solar energy has special appeal when the alternative is bottled propane lifted up the mountains by helicopter. So reasoned George Tremblay, '75, as he began a study of alternative energy sources for huts operated high in the White Mountains by the Appalachian Mountain Club. Now the*

*first solar collector designed by Mr. Tremblay as a project for the Undergraduate Research Opportunities Program (U.R.O.P.) (above) is being installed at Zealand Falls Hut. (Photo: George Bellerose from the Appalachian Mountain Club)*

## Students Design Self-Contained Space Colony

*The following article describing work during the spring term by students in 16.86, Advanced Systems Engineering, offered by the Department of Aeronautics and Astronautics, is reprinted from the May 16 issue of the Boston Sunday Herald Advertiser. Mr. Kornfeld is Science Writer on the Newspaper's staff.*

**By Joseph Kornfeld**

It spins, grows its own food, and deflects an occasional meteorite. It's a satellite space colony, and while it exists only on paper, M.I.T. students have designed it with awesome and painstaking professionalism, as though money and lives really depended on it.

This orbiting, human beehive, a container the size of ten football fields, is intended as an industrial way-station between the earth

and the mineral-rich moon. It was conceptualized years ago by Professor Gerald O'Neil of Princeton University.

But the details come from 14 students in an M.I.T. engineering course, who spent a semester planning it down to the last bolt.

Last week, in a crowded lecture hall, they submitted the plan to teachers and other students at the school. The satellite would be assembled from scratch in space, with ore ferried from the moon and smelted into steel. Solar mirrors would gather enough energy to provide 1,000 inhabitants with all the electricity and crops they needed.

A leak in the metal hull? Easily detected and quickly repaired. Even a major puncture need not spell catastrophe, because biological research shows that 48 minutes would elapse before hypoxia and other symptoms of oxygen deprivation would immobilize the inhabitants.

No, the colony isn't science fiction, and the torque ratios, the stress figures, and the cost break-downs prove it.

The students were even more impressive during a question-and-answer session which followed.

What, somebody asked, about all the pressure on the satellite's one window?

That was Tom Stagliano's department. He flipped to some figures. "Right. We've calculated that the maximum stress couldn't exceed 50,000 p.s.i. and the glass we use can take at least 100,000."

And those meteorites? Up jumped another student. "The probabilities are that we'd get a 1.5 gram meteorite hitting every 60 years at 30 kilometers per second. The alloy we use for the hull would be too thick for penetration."

The students worked under Professor John F. McCarthy and Dr. Oscar Orringer. McCarthy, when he was a research executive at North American Rockwell, was in charge of engineering the command and service modules for the Apollo moon project. "But I was only a catalyst in this course. The work and the decisions were the students'," he says.

McCarthy calls the design "quite feasible." "One of its virtues is that it doesn't call for technology that we don't already have. The same was true of the Apollo project, which is one reason for its success."

N.A.S.A. will take a look at the blueprints this summer, when three students in the class will take part in a conference the agency is holding in Mountainview, Calif. But the main purpose of the class was not space colonization and moon-mining. It was to simulate the team-work and problem-solving that industry will require from the students when they graduate.

"We really felt as if we were working under a contract in the real world," says Edward Crawley, a senior who helped decide how workers could build the colony while floating in space.

"We had to parcel out the tasks, coordinate, and come up with the design and costs in a set period of time."

The space colony would belong to a three-part network. Iron and aluminum-rich rock would be scooped from the lunar surface, processed at the man-made satellite and shipped back to earth. The students concentrated on the details of the satellite alone and admit they're not sure if the entire operation is realistic.

But the satellite, they insist, is. For its location, the students chose a point, called L-5, which puts the colony at an equal distance from earth and moon — 240,000 miles — and keeps it there. Even though all three bodies are following their separate orbits, mathematics guarantees they will always form the same pattern, like fixed points on a moving equilateral triangle.

The colony resembles a metal cylinder, except that each end would be domed, instead of capped, for greater resistance to gravity and other stresses. To see the wisdom of this design, watch what happens to

the flat ends of a full soda can when you squeeze it.

The satellite has only two apertures, one at each end. One, topped by a giant basin-like mirror, would gather the sun's energy. The other would admit people and materials.

Small, external rockets would start the vessel spinning and the laws of inertia would keep it twirling for its projected 30-year-life-span. This gyroscopic motion would create gravity for a populace that would otherwise be floating weightlessly and it would also keep the cylinder in the same posture, perpendicular to the rays of the sun.

Why not, instead, point the end-window directly at the sun? The class considered this possibility, but realized that, in addition to spinning and orbiting, the cylinder would have to be constantly flopping in order to stare the sun straight in the eye.

Here it could maintain a stable space-worthy posture and still catch solar rays as they bounce off the mirror, like wind off a cunningly positioned sail.

Solar batteries would harness some of the sunlight for electricity. The rest would be dispersed by a system of mirrors through the interior. It would shine on the wheat and tomato fields, the shops and the factories. When the workers are home and anxious for bed, night would arrive courtesy of curtains drawn across the mirrors.

The vessel, like a ship's hull, would be double-shelled. The space between the two metal surfaces would be filled with bags of lunar dirt, which would shield the inhabitants from cosmic radiation. Originally, the class designed the inner living compartment to spin inside a stationary outer shell.

But this created problems. The jacketing space between both shells would have to be a vacuum, and the result would be a kind of space thermos that would trap heat and roast its inhabitants. Rather than monkey with costly air-conditioning, the class clamped both shells in permanent alignment and rotated the cylinder as a whole.

"It was a major switch in plans," says McCarthy, "and it meant scrapping about 100 hours of work already done. But it was a wise decision and, again, entirely the students' own."

Oxygen? It could be extracted from moon-rock in enough supply for a human atmosphere. But how on earth — or rather, in space — would the hull be constructed? Here, with considerable simplification, is the ingenious plan of Crawley and two classmates.

Outer-space hard-hats would start with a steel skeleton that resembles a goal-post fastened to a thin rod instead of a dirt field. At that rod — or base — temporary factory sheds would transform lunar rock into steel plates. As these come off the assembly line, quality-checked by ultrasonic devices, a kind of giant hula-hoop which encircles the goal-post would come into action.

The hoop could be raised or lowered and would also serve as a rail, around which a

crane would move. Like one of those tower cranes used for high-rise construction, this vehicle would have great mobility. It would move plates up, down and around, pinning them to the scaffold of what eventually would be a cylinder.

Crawley was thorough as well as bold. He pored through catalogues, studying the size and tonnage of America's industrial machinery to make sure equipment would fit in his work-shed. "Wow!" he says, "I never knew a rolling mill weighed 2,000 tons."

His classmates were equally resourceful. Wally Acree, in charge of safety, decided to honeycomb the shield-space between the shells with air-tight compartments, each equipped with a pressure gauge. If one sprung a leak, the others would hold and an alarm would bring space-suited repairmen running.

Dave Akin time-tabled the entire project at 16 years and "costed it out" at \$69 billion. Actually it would be more. What economists call an "opportunity cost" — the estimated loss for not having put the same money in real-estate or stocks — would bring the tab to \$169 billion.

"That's staggering," says Crawley, "but it's a sad fact of most long-term scientific projects. And that's one of the things we were here to learn about." □

## All Screwed Up in Physics

A three-foot, left-handed aluminum screw, the symbol of success in the annual "Institute Screw" competition promoted each year by Alpha Phi Omega, now sits in the office of Professor Judith Bostock, administrator of 8.02, the required second-term undergraduate physics courses. The award has the same left-handed aspect as the trophy which represents it — a tribute by undergraduates to a member of the M.I.T. administration or faculty whose job is a hard or unpopular one, and who in fulfilling that job manages to meet students' expectations of frustration and even offensiveness.

Runners-up in this year's competition were Nancy J. Wheatley, '71, Assistant to the Vice President of the Alumni Association, and Professor Wayne V. Andersen, Chairman of the Committee on Visual Arts. Ms. Wheatley earned her "big screw" reputation while in charge of Institute houses and their dining halls as assistant Dean for Student Affairs (until November, 1975), and Professor Andersen's citation was related to his association with the Institute's growing collection of campus sculptures.

The "Institute Screw" competition is a fund-raising gimmick; votes are bought — one cent per vote — and the proceeds go to the winner's favorite charity. This year's total, says Chairman Hassan Alam, '78, was just over \$350. □



## A New Head for Chemistry



J. M. Deutch

John M. Deutch, '61, who has been a member of the faculty since 1970, is Head of the Department of Chemistry effective July 1. He succeeds Professor Glenn A. Berchtold, who returns to research and teaching after serving the customary five years as Head.

Professor Deutch has shared responsibility for the undergraduate course in Chemical Equilibrium, and he is in charge of the course in Statistical Mechanics. His research interests are in the structure of fluids, dielectrics and magnetism, light scattering, and polymer theory.

Professor Deutch received undergraduate degrees simultaneously from M.I.T. (chemical engineering) and Amherst (history and economics); his Ph.D. is from M.I.T. (1965), and he taught at Princeton for four years before returning to the Institute. He has been a member (1970 to 1974) of the National Science Foundation's Advisory Panel for Chemistry, and he is now a member of the Defense Science Board and the Army Scientific Advisory Panel.

When he announced the change, Robert A. Alberty, Dean of the School of Science, paid a special tribute to Professor Berchtold as Department Head. During his tenure, said Dean Alberty, undergraduate majors in chemistry increased 30 per cent, and there were "significant" increases in departmental research. Professor Berchtold has "guided the Department with imagination and skill during this time of expansion," said Dean Alberty. □

## Soderberg Professor

John G. Kassakian, '65, Assistant Professor of Electrical Engineering, is the first holder of the Carl Richard Soderberg Professorship in Power Engineering.

The post honoring Professor Soderberg, for 22 years a member of the M.I.T. faculty, is designed for "promising members of the faculty who want to enhance their career development in teaching and research." Professor Kassakian will use the Professorship funds to develop work in power conditioning, conversion, and control systems; the goal, says Alfred A. H. Keil, Dean of the School of Engineering, is to establish at the Institute "a viable and active program in the field of power electronics."

Professor Kassakian joined the M.I.T. faculty in 1973 to work in the Electric Power Systems Engineering Laboratory, following work with the Charles S. Draper Laboratory and Texas Instruments, Inc. He holds three degrees from M.I.T. in the field of electrical engineering. □

*John G. Kassakian, '65 (right) will use funds from his Carl Richard Soderberg Professorship to develop teaching and research in power electronics in the Electric Power Systems Engineering Laboratory. He is the first Soderberg Professor, a chair honoring C. Richard Soderberg, '20 (left), who was Dean of Engineering from 1954 to 1959 and has gained international recognition for pioneering work in power engineering, notably in the design and development of turbine engines.*

ices which his gift might honor. Two examples this year, when the committee found itself unable to choose a single candidate; Billard Awards were presented during the Technology Day luncheon to:

— **Bernard S. Gould**, '32, Professor of Biology, for "extraordinary service" as academic adviser to premedical students.

— **Walter L. Milne**, Assistant to the Chairman of the Corporation and Special Assistant to the President for Urban Relations, for "superb staff support" and "selfless dedication."

For more than a decade Dr. Gould was the Institute's official premedical adviser, and he continues to help students informally make the decisions and surmount the hurdles involved in preparing for and entering medical school. Meanwhile, in addition to providing staff support for the Chairman of the Corporation, Mr. Milne spends countless hours — including long evenings and frustrating political palaver — listening to Cambridge's problems and helping M.I.T. relate to them.

Mr. Billard established the fund as a memorial to his mother, and Billard Awards carry \$500 honoraria. □

## Billard Awards to Gould, Milne



B. S. Gould



W. L. Milne

When Gordon Y. Billard, '24, established a fund "for special awards to members of the faculty" in 1951, he could hardly have foreseen the many kinds of extraordinary serv-

## Adjunct Professors

The first two Adjunct Professors in M.I.T.'s history were named this spring: Guillian C. Tesoro in the Department of Mechanical Engineering and John R. Wiley, '33, in the

Department of Aeronautics and Astronautics; both had earlier held the rank of Visiting Professor.

The appointment of Adjunct Professors was approved by the faculty in 1974; the purpose was to accommodate senior teachers and researchers at the Institute who had not risen through traditional academic backgrounds. Dr. Tesoro, who is an internationally recognized expert in the science and technology of polymers, is associated with the fibers and textiles group in mechanical engineering; Mr. Wiley, formerly Director of Aviation for the Port Authority of New York, teaches airport planning and air transport management in the Flight Transportation Laboratory. □

## Physicist Turned Dance Critic



For Alan M. Kriegsman, '48, a potential career in physics has turned into that of a dance critic, with great success. He has been awarded the Pulitzer prize for criticism for his work as dance critic for *The Washington Post* — the first time the prize has gone to a critic in his field.

Today is a time of individual dance talents — and new approaches in dance journalism. "This is an era," writes Mr. Kriegsman, "which tends to shy away from the literal and verbal and turn toward the visual and kinetic experience. It is also an era of body awareness and sense exploration."



*Walter A. Rosenblith, Provost of the Institute, was made an Honorary Member of the Alumni Association by the Board of Directors during the afternoon of June 3. Hardly three hours later he was also an Honorary Member of the Class of 1951, when a vote was taken during the Boston Pops concert. He is the 21st Honorary Member of the Association — a "tireless worker for the Association and the Institute," said Howard L. Richardson, '31, President, upon introducing Dr. Rosenblith at the Technology Day Luncheon. And Breene Kerr, '51, surmised that "no class in the history of the Institute had moved faster to accept a new Honorary Member of the Association" than 1951. Professor Rosenblith said he was "speechless," but that was something of an overstatement: "I cannot tell you how happy, grateful, and proud I am," he told 1,200 alumni at the Luncheon; and to the Class of 1951 he noted that he had come to the Institute just as they graduated; "did you know that, or will they do anything to increase the size of that class?" (Photo: Calvin Campbell)*

His topics have been varied: the Steinway piano dynasty; the science of holography and its application to the arts; Ingmar Bergman's opera movie, "The Magic Flute"; new video technology and its effect on home entertainment; the exodus of artists from the Soviet Union.

He covers new events related to culture: a National Symphony strike, U.S. House and Senate hearings on various art bills, and Presidential press conferences, for example. "At the *Post* I've learned to be a journalist as well as a critic. I've been surprised to find myself enjoying it," he says.

Mr. Kriegsman was born in Brooklyn and grew up in Far Rockaway, N.Y. He studied physics at M.I.T., then music at Columbia University, where he earned an M.A. and completed course work and examinations for a Ph.D. in musicology. He was a member of the music faculty at Columbia for five years, taught at Barnard and Hunter Colleges and the Juilliard School. He recently served for three years on the Visiting Committee on the Humanities at M.I.T. □

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Two student favorites were among members of the staff retiring this year: Gerald M. Reed, Jr., '34, Sailing Master (above, right, receiving a retirement gift from Stuart A. Nelson), and Silvio N. Vitale, Fencing Master (shown, right, sharing a toast with fellow-retirees William V. Tennis, physical plant, and William B. Gove, Office of Sponsored Programs.)

## More Than 2,000 Years of "Collective Wisdom" Leaves as 110 Staff Retire

A total of some 2,000 years of service were represented among 110 members of the M.I.T. community — including the Lincoln and Draper Laboratories — who reached retirement age on July 1.

Speculating on their reaching what President Wiesner called "one of the great milestones of life," Philip A. Stoddard, '40, Vice President, said he was "struck with the collective wisdom" represented in such a group. And Paul E. Gray, '54, Chancellor, saluted the retirees' contributions to "the quiet sense of purpose which characterizes the Institute, . . . the special satisfaction that comes from working in this special place."

Brandon G. Rightmire, Sc.D. '41, retired as Professor of Mechanical Engineering with 41 years of service to the Institute — the longest tenure of any. But two other retirees had arrived at the Institute in 1936 and so had 40 years of service — Professor William T. Martin (mathematics) and Gerald M. Reed, Jr., '34, Sailing Master. In addition to the 11 members of the faculty and academic administration whose careers are summarized in the adjacent columns, retirees this year included Margaret Bergmann, Administrative Assistant in Civil Engineering; Helen Clifford, Assistant to the Treasurer of the Alumni Association; Ruth S. Goodwin, Assistant Registrar; C. Warren Smalzel, S.M. '45, Institute Secretary for Corporations; and Silvio N. Vitale, Fencing Master. The roster of faculty retirees included two former Chairmen of the Faculty — Professors Charles P. Kindleberger and William T. Martin. □

### William H. Brown, '33

In 36 years on the teaching staff of the Department of Architecture, William H. Brown has taught countless M.I.T. students the technology by which buildings are designed and built — how esthetics are translated into drawings and specifications, and how that process tests the design and the designer. For the past 30 years he has combined teaching with his own architectural practice as President of William Hoskins Brown Associates, Boston. Architectural

assignments for M.I.T. have included refurbishing of the Alfred P. Sloan Building when it was acquired for the Institute's use from Lever Brothers Co. and the dining hall for Burton-Conner House. Professor Brown was also the architect of 100 Memorial Drive, the widely-honored apartment house built adjacent to the M.I.T. campus in 1950.

### Mason Haire

Mason Haire, who retires as Sloan Professor of Management, first came to M.I.T. for three years in 1946 to be Assistant Professor of Industrial Relations. He returned two decades later to be Visiting Professor and, in 1967, Professor of Organizational Psychology and Management; meanwhile he had been a member of the Department of Psychology at the University of California (Berkeley). As a leader of the Sloan School's Organization Studies Group in the 1960s he brought about a synthesis of insights in behavioral science with those in such apparently disparate fields as computer science, economics, and the mathematics of model building. More recently he has used innovative mathematical models to integrate organizational objectives, reward systems, management development, and the movement of personnel.

### Harold R. Isaacs

Harold R. Isaacs, Professor of Political Science, is a journalist-turned-teacher. After graduating in 1930 from Columbia University he was a reporter of Chinese and Asian affairs in Shanghai, Honolulu, Peking, New York, Washington, India, and Southeast Asia for more than 20 years before coming to the Institute as Research Associate (1953) in the Center for International Studies. For the past decade the transition has been complete: Professor Isaacs has been Professor of Political Science, teaching subjects relating world affairs and human relations — problems of national identity, racialism, ethnicity, and pluralism. He has been a prolific writer; his most recent book is *Idols of the Tribe: Group Identity and Political Change*, and he will con-

tinue work at M.I.T. on emerging pluralisms in American society.

### Myer M. Kessler, '39

Myer M. Kessler, '39, has had a varied career spanning science, bibliography, and scientific communication. His M.I.T. degrees in biophysics (S.M. 1940) were followed — after World War II service — by graduate work in physics and appointments at the National Bureau of Standards and Brandeis University; then came a decade of work at Lincoln Laboratory on the design and evaluation of weapons and detection systems — especially on the properties of microwave radar over such reflecting media as earth and water. His appointment in 1959 to chair a committee on communication problems at the Lincoln Laboratory led to an expansion of Lincoln's library services — and to Dr. Kessler's interest in scientific communication in general. By 1962 he was in charge of an extensive research and development program to create computer software for text processing and bibliographic information handling in the M.I.T. Libraries — and later to apply computer techniques to library management systems. Since 1973 he has been Coordinator of Technical Data Systems in the M.I.T. Information Processing Services.

### Charles P. Kindleberger

Charles P. Kindleberger, Ford Professor of Economics, is an authority on international monetary affairs and European economic history. Following academic work at the University of Pennsylvania and Columbia, he began his career in this field at the Federal Reserve Bank of New York, and he came to M.I.T. after World War II. The quickness of his mind is reflected in the speed of both his tongue and pen; Professor Kindleberger is a popular lecturer and a prolific author of articles and books — the latest of the latter being *The World in Depression, 1929-1939*, a study in economic history. His *International Economics* is a highly successful text.



W. H. Brown



M. Haire



H. R. Isaacs



M. M. Kessler



C. P. Kindleberger



R. C. Lord

### Richard C. Lord

Richard C. Lord, Professor of Chemistry, is a distinguished spectroscopist known for work on both chemical and biological applications of this specialized technique and for his administration of M.I.T.'s Spectroscopy Laboratory as a model for interdepartmental research. At the end of World War II he received the Presidential Certificate of Merit for defense-related work in the field, and it was then that he embarked on the interdepartmental laboratory concept leading to applications for spectroscopy in many technical fields, including notably molecular biology, and its extension through the use of infrared and laser sources. During two decades since 1950 Professor Lord has been responsible for training more than 2,000 scientists in infrared spectroscopy at summer session which he organized, and he holds many honors in the field.

### William T. Martin

Professor William T. Martin first came to M.I.T. to teach mathematics in 1936, shortly after completing academic and postdoctoral work at the University of Illinois, Princeton, and the Institute for Advanced Study; he has been at the Institute ever since, except for four years during World War II when he headed the department at Syracuse University. Following important contributions to mathematical knowledge, Professor Martin has recently focused on problems of education. He was the first Director of M.I.T.'s Division for Study and Research in Education from 1973 to 1975, and he has been a principal contributor to the Education Development Center, where he was chairman of steering committees on projects in African education and on school mathematics. He has also studied the British Open University system in relation to D.S.R.E. programs.

### Brandon G. Rightmire, Sc.D. '41

Professor Brandon G. Rightmire joined the M.I.T. faculty in 1942 after completing graduate work in the Department of Mechanical Engineering (his undergraduate work was at Ohio State University), and ever since then he has been a consistent, quiet contributor to that Department's teaching and research programs. He has made problems at the interfaces of materials —

including especially lubrication and wear — his special field of expertise, and substantial contributions to the theory and practice of lubrication and lubricating materials are credited to him. Earlier his professional work spanned fluid mechanics, applied mechanics, and thermodynamics.

### William Speer

The "Old Mr. Chips" aspect to William Speer's demeanor is neither contrived nor superficial; as Associate Dean for Student Affairs he has been a counsellor to countless M.I.T. undergraduates, and he has for many years been in charge of counselling activities in the Dean's office. Dean Speer's entire career has been in education — as Director of Admissions and of Student Life at Rutgers University, as Headmaster of the Loomis School and the Gilman School, and — since 1953 — as Associate Dean at the Institute.

### Carroll L. Wilson, '32

When the Mitsui Professorship in Problems of Contemporary Technology was created at M.I.T., Professor Wilson's selection as its first occupant was obvious: few at the Institute have experience equal to his in technical administration, and none has combined that interest so effectively with concern for the consequences of technology and their management. After holding administrative posts at M.I.T. until 1940, Professor Wilson was associated with National Research Corp., the Atomic Energy Commission (he was its first General Manager from 1947 to 1950), National Research Corp., Climax Molybdenum, and Metals and Controls Corp. He then returned to teach management at the Institute, and he has recently organized and conducted studies of Critical Global Environmental Problems (1970), Man's Impact on Climate (1971), and Alternative Energy Strategies (1975).

### Walter Wrigley, '34

Throughout his career at M.I.T., Professor Walter Wrigley, '34, has been closely associated with the Instrumentation (now Draper) Laboratory, most recently as its Educational Director. Following graduate study at the Institute (Sc.D. 1941), Pro-



W. T. Martin



B. G. Rightmire



W. Speer



C. L. Wilson



W. Wrigley

essor Wrigley was for six years with Sperry Gyroscope Co.; then he returned to Cambridge to become Assistant Director of the Instrumentation Laboratory. Professor Wrigley joined the M.I.T. faculty in 1951, when he also became the Laboratory's Associate Director; since then his teaching has been in the fields of instrumentation and astronautics, including courses in inertial guidance, space dynamics, and dynamical astronomy.



E. C. Littmann



W. H. Mills



H. L. Richardson



P. M. Cook



R. Landau



C. M. Mueller



K. H. Olsen



H. F. Whitaker



J. A. Moody



E. O. Vetter

## Ten Changes on the Corporation

Five new faces will be present on October 1 when the M.I.T. Corporation gathers in Cambridge for the most important — the "annual" meeting — of its four traditional yearly sessions. And five members of the Corporation will be present with new credentials — all the result of elections at the Corporation's meeting preceding the Commencement Exercises on May 28.

Of the five new faces, three are nominees by members of the Alumni Association in the annual national election:

— **Ellis C. Littmann**, '33, President and Chairman of the Board of Nixdorff-Krein Manufacturing Co., St. Louis. Mr. Littmann, active for many years in the Alumni Association, studied business and engineering administration at the Institute and joined his present firm upon graduation. He's Vice President of the Association, a member of the Alumni Fund Board and Corporation Development Committee, and winner of the Bronze Beaver Award (1969).

— **William H. Mills**, '34, founder and President of Mills and Jones Construction Co., St. Petersburg, Fla. His Course was civil engineering, and Mr. Mills now heads one of the leading construction firms in Florida, where he is also a leading public citizen — former President of the St. Petersburg Chamber of Commerce, a member of the Florida Council of 100, and a director of several financial and service institutions. Mr. Mills was a member of the Corporation Visiting Committee for the Department of Civil Engineering from 1959 to 1973; he has been a member of the Corporation Development Committee since 1965 and is now a member of the Leadership Committee for the \$225-million Leadership Campaign.

— **Howard L. Richardson**, '31, whose one-year service as President of the Alumni Association ended on July 1. Mr. Richardson graduated in electrical engineering, formerly headed the Silicon Transistor Corp., and is now a consultant and corporate director. His term as President of the Alumni Association climaxed a long record of service to the Association and M.I.T.: President of his Class of 1931, a long-time member of Corporation Visiting Committees, winner of the Bronze Beaver (1969), and a member of the Corporation Development Committee since 1971.

Three Term Members of the Corporation were elected to Life Memberships, effective July 1:

— **Paul M. Cook**, '47, President of Raychem Corp., Menlo Park, California. A Term Member of the Corporation since 1971, Mr. Cook is a leader in San Francisco alumni activities; leader of the sponsoring committees for the recently completed Gilliland Professorship and Landau Buildings, both serving the Department of Chemical

Engineering; and a leader (as a member of the National Steering Committee) in the Leadership Campaign.

— **Ralph Landau**, Sc.D. '41, Chairman and Chief Executive Officer of Halcon International, Inc., of New York City. M.I.T.'s new chemical engineering building is named in honor of this major donor, a principal figure in the U.S. chemical industry. He has been a Term Member of the Corporation since 1972, a member of the Corporation Development Committee since 1966, and a member of the M.I.T. Energy Laboratory Advisory Board since 1973.

— **Carl M. Mueller**, '41, Managing Partner of Loeb, Rhoades and Co., New York City. Elected a Term Member of the Corporation in 1969, Mr. Mueller almost immediately took influential roles in the Corporation's work, becoming a member of its Investment Committee in 1969 (Chairman beginning in 1975) and of its Executive Committee in 1970. He is also a member of the Corporation Development Committee and of the National Sponsoring Committee for the Leadership Campaign.

**Kenneth H. Olsen**, '50, founder and President of Digital Equipment Corp. of Maynard, Mass., was named to his second five-year term as a member of the Corporation. Mr. Olsen left M.I.T.'s Lincoln and Digital Computer Laboratories to form his highly successful company, and he has retained an active interest in the Institute ever since, principally as a member — and since 1973 Chairman — of the Corporation Visiting Committee for the Department of Electrical Engineering and Computer Science.

**Helen F. Whitaker**, Trustee of the Whitaker Foundation of Harrisburg, Penn., joined the Corporation on July 1 as a Term Member (five years). Mrs. Whitaker's late husband, Uncas A. Whitaker, '23, shared her interest in the life sciences, and together they were for many years leaders in the development of the life sciences at the Institute. Their names together are honored on a major M.I.T. building which houses elements of the Departments of Biology and of Nutrition and Food Science.

**James A. Moody**, '75, of Kansas City, Mo., has been elected a member of the Corporation for five years in the category of Representative from Recent Classes. As an undergraduate in management (S.B. 1975) and electrical engineering and computer science (S.B. 1976), Mr. Moody had the unique honor of winning both the William T. Steward Award and the Karl Taylor Compton Prize to recognize contributions to undergraduate life. His election to the Corporation is the result of a national ballot by members of the Classes of 1974, 1975, and 1976.

In addition to the new members elected in June, **Edward O. Vetter**, '42, formerly Executive Vice President of Texas Instruments, Inc., began on July 1 a one-year term as a member of Corporation *ex officio* by virtue of his election as President of the M.I.T. Alumni Association. □

## Honors to Chomsky as Institute Professor



N. A. Chomsky

The highest faculty rank at M.I.T. — that of Institute Professor — has been given by his colleagues to Noam A. Chomsky, Ferrari P. Ward Professor of Modern Languages and Linguistics.

Professor Chomsky's research on the nature of language has revolutionized linguistic science and has strongly influenced both psychology and philosophy. President Jerome B. Wiesner, who made the announcement, said colleagues throughout the world agree that he is "clearly one of the most prominent contemporary academic figures in linguistics and in the psychology and philosophy of language."

Professor Chomsky joined the M.I.T. faculty in 1955, following undergraduate and graduate work at the University of Pennsylvania; he has since then lectured and served on leaves of absence at the Institute for Advanced Study (Princeton), the University of California (Berkeley), Oxford, Cambridge, and London Universities, and the University of British Columbia. He is the author of many articles, seven books in the field of linguistics, and three controversial books of political comment.

Professor Chomsky's major contribution has been what is called the theory of "transformational generative grammar." Even the most disparate languages have many similarities in form and structure, and Professor Chomsky proposes that these represent basic intellectual similarities which can be traced to the common genetic heritage of all humans, an innate knowledge with which all humans are born.

This theory contrasts sharply with the view, held widely by philosophers and psychologists, that humans acquire by experience most of the knowledge that makes their linguistic communication possible. The debate, a direct result of Professor Chomsky's challenge, continues among linguists, philosophers, and psychologists.

Institute Professorships at M.I.T. are granted upon the recommendation of a special faculty committee, which acts only upon nominations by members of the faculty; it is a rank reserved for "scholars of special distinction." □

## Individuals Noteworthy

### Kudos: Honors, Awards, Citations

To **Amos E. Joel, Jr.**, '40, Consultant at Bell Telephone Laboratories, Holmdel, N.J., and to **Raymond W. Ketchledge**, '42, Executive Director of the Ocean Systems Div., Whippany, N.J., the first Alexander Graham Bell Medal of the Institute of Electrical and Electronics Engineers . . . to **John G. Linvill**, '43, Professor and Executive Head of the Electronics Lab at Stanford University, the Educational Medal of the I.E.E.E. . . . to **Merle K. Loken**, '48, Professor and Director of the Division of Nuclear Medicine at the University of Minnesota's Medical School, an Alumni Achievement Award of the Alumni Association of Augustana College.

To **Alan M. Kriegsmann**, '48, Dance Critic for the *Washington Post*, the 1976 Pulitzer Prize for Criticism . . . to **Robert W. Mann**, '50, Whitaker Professor of Biomedical Engineering at M.I.T., the Isabelle and Leonard H. Goldenson Award of United Cerebral Palsy, their top recognition for technology related to neuromuscular disabilities . . . to **Roger J. Hawks**, S.M. '67, Professor of Mechanical and Industrial Engineering at Clarkson College, the 1976 Ralph R. Teeter Educational Award of the Syracuse section of the Society of Automotive Engineers . . . to **Manson Benedict**, Ph.D. '35, Emeritus Professor of Nuclear Engineering at M.I.T., the Founder's Medal of the National Academy of Engineering.

To **Peter A. Wolff**, Professor of Physics and Associate Director of the Center for Materials Science and Engineering at M.I.T., a 1976 Guggenheim Fellowship Award of the Guggenheim Foundation . . . to **Jule J. Charney**, Alfred P. Sloan Professor and Head of the Department of Meteorology at M.I.T., the William Bowie Medal of the American Geophysical Union . . . to **John S. Lewis**, Associate Professor of Geochemistry and Chemistry in the Department of Earth and Planetary Sciences at M.I.T., the James B. Macelwane Award, also of the American Geophysical Union . . . Two M.I.T. professors were honored as Distinguished Members of the Iron and Steel Society of the American Institute of Mining, Metallurgical and Petroleum Engineers: Professor Emeritus **John Chipman**, and Professor **John F. Elliott**, Sc.D. '49, of the Department of Materials and Science and Engineering.

To **Alex W. Dreyfoos, Jr.**, '54, President of Photo Electronics Corp. and Television Station WPEC, West Palm Beach, Fla., membership in the Young Presidents Organization . . . Two M.I.T. alumni were honored in their retirement from Purdue University's Calumet Campus by the appointment to the rank of Professor Emeritus: **Charles E. Columbus**, S.M. '43, and **Loren E. Brunner**, S.M. '42 . . . Four assistant professors at M.I.T. were awarded two-year Sloan Fellowships for Basic Research from the Sloan

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Foundation: **Richard R. Schrock** and **Edward I. Solomon** of the Department of Chemistry; and **John D. Joannopoulos** and **Paul C. Joss** of the Department of Physics ... to **Janet M. Corpus**, a Ph.D. candidate in the Department of Urban Studies and Planning at M.I.T., a Kent Fellowship of the Danforth Foundation ... to **Michael Delaney**, '75, a university fellowship of the University of Massachusetts at Amherst.

New Members of the American Academy of Sciences: **John I. Brauman**, '59, Professor of Chemistry at Stanford University ... **Walter A. Rosenblith**, Provost and Professor of Communications Biophysics at M.I.T. ... **John Ross**, Ph.D. '51, Professor of Chemistry at M.I.T. ... **Joaquin Mazdak Luttinger**, '44, Professor of the Department of Physics at Columbia University ... and **Kenneth Gardiner McKay**, Sc.D. '41, Executive Vice President of Bell Telephone Laboratories, Inc., Murray Hill.

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### Fellows

Three new fellows of the American Institute of Chemical Engineers: **Edward J. Fradkin**, S.M. '46, Vice President of Scientific Design Co., Inc., New York, N.Y., also Vice Chairman of the New York Section of A.I.Ch.E.

... **Stanley B. Zdonik**, '41, Manager of the Process Department at Stone and Webster Engineering Corp., Boston ... and **Howard H. Reynolds**, Sc.D. '39, Professor and Chairman of the Chemical Engineering Department at Lowell University, Lowell, Mass.

... **Daniel J. Fink**, '48, Vice President and General Manager of the General Electric Space Division, to Fellow of the American Association for the Advancement of Science ... **Theodore R. Madden**, '49, Professor of Geophysics in the Department of Earth and Planetary Sciences at M.I.T., to Fellow of the American Geophysical Union.

### Counselors: Officers, Directors, Advisors

Two elected to the Council of the National Academy of Engineering for three-year terms: **Ralph Landau**, Sc.D. '41, Chairman of the Board and Chief Executive Officer of Halcon International, Inc., New York, N.Y.; and **Frederick A. L. Holloway**, Sc.D. '39, Vice President for Science and Technology at Exxon Corp., New York, N.Y. ... **E. Kirkbride Miller**, '41, Director and Chief Executive Officer of the T. Rowe Price Growth Stock Fund, to Chairman of the Board of that organization ... **Charles E. Reed**, '37, Senior Vice President for Corporate Strategic Planning of the General Electric Co., Fairfield, Conn., to a three-year term on the Board of Trustees at the University of Bridgeport.

**Roger H. Wingate**, S.M. '37, Senior Vice President of Liberty Mutual Insurance Co., to their Board of Directors ... **Wylie S. Robson**, S.M. '56, General Manager of the International Photographic Division and Executive Vice President of Eastman Kodak Co., to the Board of Directors of The Carborundum Co. ... **Herbert Shivek**, '43, President of Serve-O-Lift Corp., Boston, to the Board of Directors of New England Sinai Hospital ... **Herbert Fox**, '60, Dean of the Division of Science and Technology at the New York Institute of Technology, to Vice President for Education of the American Institute of Aeronautics and Astronautics.

**Victor F. Weisskopf**, Institute Professor Emeritus of Physics at M.I.T., to President of the American Academy of Arts and Sciences ... **James E. Hubbard**, '77, to Chairperson of the Northeast Section of the National Society of Black Engineers ... **Irma Johnson**, Science Librarian at M.I.T., to Vice President and President-elect of the New England Chapter of the Association of College and Research Librarians ... **Douglas Sinclair**, '60, Professor of Optics at the University of Rochester, to Chairman of the U.S. National Committee for the International Commission for Optics.

**Hoyt C. Hottel**, '24, Professor Emeritus

in the Department of Chemical Engineering at M.I.T., to the steering committee that will supervise the revision of the National Research Council's reference volume, *Chemistry of Coal Utilization* ... **Paul E. Gray**, '54, Chancellor of M.I.T., to the Board of Directors of the M.I.T. Development Foundation, Inc. ... **Carl M. Mueller**, '41, Managing Partner of Loeb, Rhoades and Co., to a Trustee of the Carnegie Corporation of New York.

## Frederick G. Keyes, 1885-1976: "Eminent Contributor to Physical Chemistry"



F. G. Keyes

Frederick G. Keyes, Professor Emeritus of Physical Chemistry who was Head of the Department of Chemistry for 23 years beginning in 1922, died in Cambridge on April 14. He was 90.

Dr. Keyes, a pioneer in thermodynamics and low-temperature research, came to M.I.T. in 1910 from Brown University, where he completed graduate work (Ph.D.) in 1909. Following several years of collaboration with Professor Arthur A. Noyes, '86, he became Director of the Research Laboratory of Physical Chemistry following World War I; he was then a leader in basic research on intermolecular forces and the physical properties of gases. Later Professor Keyes' interest in thermodynamics led him to work with Joseph H. Keenan, '22, Professor of Mechanical Engineering, on *Thermodynamic Properties of Steam*, the basic "steam tables" now used throughout the world in modern steam generating plant design. At the same time, Professor Keyes was pursuing low-temperature research which led to the establishment at M.I.T. of the first center for low-temperature research in the U.S.

Following retirement from the Institute in 1950, Professor Keyes maintained an active professional role in research at M.I.T. and as a consultant in chemical thermodynamics. He was widely honored in chemistry, and the American Society of Mechanical Engineers cited him for its highest honor as "an eminent contributor to our knowledge of physical chemistry." □

## Samuel Berke, 1894-1976

Samuel Berke, '15, former President and Chairman of the Board of Mr. Boston Distiller Corp., who had been an active participant in Corporation Committees and other alumni services to the Institute, died in Lakeville, Conn., on April 14. He was 82.

After graduating in mechanical engineering, Mr. Berke pioneered in the manufacture of automotive replacement parts; he joined Mr. Boston Distiller Corp. in 1936.

Mr. Berke served on the Visiting Committee for the Department of Modern Languages from 1955 to 1962 and during that period helped fund the Institute's first language laboratory. Later he established the Industrial Management Associates Award, given each year for the best thesis in the Sloan School of Management, and he was a member of the sponsoring committee for the Underwood-Prescott Professorship in the Food Sciences. Mr. Berke became an Honorary Member of the Corporation Development Committee last year. □

## Harold H. Carter, 1903-1976

Harold H. ("Nick") Carter, who began working at M.I.T. as an errand boy on February 2, 1918, and retired 50 years later as a Technical Instructor in the Department of Chemical Engineering, died on May 24.

A native of Maine, Mr. Carter came to Cambridge at age 15. He began to make a place for himself as a warm and colorful colleague to students and staff alike. In 1920 he became a technician in the new Department of Chemical Engineering, with which he was thereafter affiliated throughout his M.I.T. career. Mr. Carter was promoted to the academic staff in 1956.

When he retired in 1968, scores of students recalled his firm good humor and the valuable "real world" lessons they learned while trying to talk "Nick" Carter — he managed the Department's supply room — into the loan of a piece of equipment.

Meanwhile, Mr. Carter had become a leader in the community life of the Institute. He was a founding member and an officer of the Research, Development, and Technical Employees Union (independent); he ran the M.I.T. Employees Federal Credit Union — at first pretty much out of his desk — and watched it grow to assets of about \$8 million; he was a principal organizer of the annual campus blood drive, and before reaching the age of 60 Mr. Carter had donated 70 pints of blood to that program; and he was a Past Master of the Richard C. Maclaurin Lodge, A.F. and A.M., at the Institute. □

## Alvar Aalto, 1898-1976

Alvar Aalto, the distinguished Finnish architect who taught at M.I.T. in 1940-41 and again from 1946 to 1950, died in Helsinki on May 11. It was during his second period of teaching at M.I.T. that Mr. Aalto designed Baker House, the most famous of only three buildings which have been built to his designs in the U.S. □

## Robert G. Caldwell, 1882-1976

Robert G. Caldwell, who was Dean of Humanities at M.I.T. from 1939 to 1948, died in Fishkill, N.Y., on May 8. He was 94.

A member of the U.S. Foreign Service, Dr. Caldwell had served as Minister to Portugal (1933 to 1937) and to Bolivia (1937 to 1939) before his appointment at M.I.T. Following retirement at the Institute he was Cultural Affairs Attaché in the U.S. Embassies at Buenos Aires and Mexico City.

Dr. Caldwell studied at the College of Wooster and Princeton, and he held faculty posts at Wooster (1912 to 1914) and Rice Institute before joining the diplomatic service. □

## Deceased

Daniel A. Smith, '03; June 22, 1971

Charles B. Mayer, '05; February, 1976; 6457 Firmament Ave., Van Nuys, Calif.

Herbert S. Cleverdon, '10; February 13, 1976; 35 Windemere Rd., Wellesley, Mass.

Robert B. Nichols, '13; January 24, 1976; Box 700 GPO, c/o Roper, Binghamton, N.Y.

Gilbert R. Pardey, '13; January 26, 1976; 333 Grand Ave., Englewood, N.J.\*

Albert J. Hoyt, '14; March 12, 1976; c/o Lloyd Loux, National City Bank, Box 5756, Cleveland, Ohio

Bahjat A. Abdunour, '15; May 27, 1974; Rue Sadat Imm Adayme, Beirut, Lebanon\*

Seward Highley, '15; May 4, 1976; 43 Powder House Rd., Medford, Mass.\*

Henry L. Leeb, '15; April 24, 1976; Walnut Hill Farm, Gladstone, N.J.\*

Freeman C. Hatch, '16; April 3, 1976; Eastham, Mass.

Irving Fineman, '17; March, 1976; Shaftsbury, Vt.

Joseph T. Sattels, '18; May 31, 1975; 733 Edmonds Ave., Drexel Hills, Penn.

Marshall C. Balfour, '19; March 20, 1976; 111 Morgan Creek Rd., Chapel Hill, N.C.

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Wilbur S. Burbank, '19; April 11, 1975; 9 Bayberry Ln., Exeter, N.H.  
 W. Roy Mackay, '19; April 12, 1976; 1310 Magnolia Ave., Winter Park, Fla.  
 Joseph B. Margolis, '20; May 10, 1976; Sea-Air Towers 1402, 3725 So. Ocean Dr., Hollywood, Fla.\*  
 Flemmon P. Hall, '21; May 30, 1975; 1000 Vista Dr., Cherryville, N.C.  
 George F. Lull, '21; February 7, 1976; 2440 N. Lakeview, Chicago, Ill.\*  
 Edward P. Molloy, '21; March 7, 1976; 880 Lake Shore Dr., Chicago, Ill.\*  
 George F. Pieper, Jr., '21, September 5, 1972; 29 Mingo St., Milton, Mass.\*  
 Warren T. Ferguson, '22; February 24, 1976; c/o 54 Lamplighter Ln., Newington, Conn.\*  
 William B. Jones, '22; April, 1976; 1320 Woodstock Rd., San Marino, Calif.  
 Walter H. Sitz, '22; March 12, 1976; 3203 Turner Ln., Chevy Chase, Md.  
 Otis Clapp, '23; June 8, 1973; Box 59, Kennebunkport, Maine  
 Lawrence J. Tracy, '23; March 18, 1976; Box 307, 17 Shore View Dr., East Orleans, Mass.  
 Joseph R. Mares, '24; April 13, 1976; P.O. Box 686, Dickinson, Tex.  
 Thomas T. Stevenson, '24; April 26, 1976; 7732 E. Rancho Vista, Scottsdale, Ariz.  
 Frank P. Van Deren, '25; January 1, 1976; 1927 Terrace Way, Santa Rosa, Calif.  
 Edgar O'Neil, '26; July, 1974; 70 Merrion Rd., Ballsbridge, Dublin, England

R. Gordon Spear, '26; April 1, 1976; 1150 Hillsboro Beach #201, Pompano Beach, Fla.  
 Herbert H. Wilbur, '26; June, 1974; 2855 Gulf To Bay Blvd. #430, Clearwater, Fla.  
 George K. Bennett, '27; December, 1975; Stoneleigh Apts., Stoneleigh Plaza, Bronxville, N.Y.  
 Samuel S. Meadows, '27; August 2, 1975; 2 Powers Ln., Decatur, Ill.  
 François Rousseau, '27; October, 1975; 1525 Bernard West, Apt. 11, Outremont, PQ, Canada\*  
 Richard D. Hoak, '28; June 22, 1975; 11200 102nd Ave. N #128, Seminole, Fla.  
 Francis J. Donnelly, '29; March, 1976; 53 Pamela Rd., Arcadia, Calif.  
 Rodolphus A. Swan, '29; April 20, 1976; Forest Rd., Box 959, Wolfeboro, N.H.  
 Harry C. Weare, '29; April 26, 1976; c/o West Bay Manor, 2783 W. Shore Rd., Warwick, R.I.  
 John H. Foulds, '30; March 2, 1975; 194 Grove Ave., Fall River, Mass.  
 Edward F. Abbott, '31; August, 1975; 469 Myers Ave., Harrisonburg, Va.  
 John H. King, '31; April 12, 1976; 204 Renfrew St., Arlington, Mass.  
 Charles D. Luke, '31; April 18, 1976; 5607 Parkston Rd., Washington, D.C.  
 Chesley S. Young, '31; April 13, 1976; 15690 Lake Forest Dr., Sun City, Ariz.  
 Walter E. Nichols, '32; January 3, 1976; Tonela Rd., Cummaquid, Mass.  
 Frederick C. Reese, '32; May 8, 1975; 140

8th Ave., Apt. SL, Brooklyn, N.Y.  
 James C. Faria, '33; July, 1975; 581 Davison St., Fall River, Mass.  
 William W. Hartz, '34; July, 1975; 74 Spring Brook Rd., Springfield, N.J.  
 Edward E. Stritter, '36; May 6, 1976; 486 North Ave., Weston, Mass.  
 Samuel Abbott, '39; May 12, 1976; Maple St., Wilton, N.H.  
 Alton J. Wadman, '40; April, 1976; 2 Carole Ct., Silver Spring, Md.  
 James L. Erikson, '42; March 8, 1976; 5819 N. Shore Dr., Milwaukee, Wis.  
 Leonard H. Carlson, '47; April 10, 1976; 3 Circle Dr., Barrington, R.I.\*  
 Arthur R. Hull, '48; March 2, 1976; 4624 West Ridge Pl., Washington, D.C.  
 H. Allen Stormer, '50; January 13, 1976; 10228 Chesterton Dr., Dallas, Tex.  
 R. Thomas B. Peirce, Jr., '54; November 14, 1975; 228 Pine St., Philadelphia, Penn.\*  
 Thomas V. Griffiths, '57; July, 1975; 804 Via Conejo, Palos Verdes Peninsula, Palos Verdes, Calif.  
 Philip M. Dusini, '58; September, 1975; W. Surrey Rd., Keene, N.H.  
 Gerald S. Clemmer, '59; April 23, 1976; 920 Boot Rd., West Chester, Penn.  
 Paul S. Lam, '59; May 7, 1976; Block D 21st floor, 41A Stubbs Rd., Hong Kong  
 Frederick W. Reuter III, '65; February 20, 1976; 2268 Coventry Rd., Cleveland, Ohio

\* Further information in Class Review

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# Class Review

## 03

Fellow Classmates, you should now be aware of our serious position as M.I.T.'s oldest living alumni, with the death in March of Richard O. Elliot, '96. For we who lingered on the memorable Rogers steps in Boston, the present enormous M.I.T. campus is in stunning contrast to the limited and crowded classes housed in Rogers and Walker Buildings. Yet the changes are no greater than those we wrought: railroads pushed to the West Coast through unbroken forest and in sub-zero temperature, the natural power of the mighty rivers harnessed to produce electric energy.

The obituary bell tolls for the passing of our devoted classmate, **George H. Garcelon**, 92, a 20-year resident of Longmeadow, Mass. Born in Lewiston, Maine, he worked for Westinghouse Electric Co. in Springfield from 1925 to 1931 and then to East Pittsburgh Westinghouse to retire in 1950 as Manager of Control Engineering. George was an inventor of many small motors and among the first graduates in the field of electrical engineering from M.I.T.

He was a communicant of St. Mary's Church, Longmeadow, and husband of the late Frances (Baab) Garcelon, who died in 1974. He is survived by three sons, George F. of Reading, Penn., Frederick H. of Winchester, Mass., and Robert G. of Short Hills, N.J.; seven grandchildren and three great-grandchildren.

A change of address for **J. Russell Jones**, to Highland Hills, R.F.D. 2, Halifax, Va. 24558. — **John J. A. Nolan**, Secretary-Treasurer, 13 Linden Ave., Somerville, Mass. 02143

## 07

Classmate **Milton E. MacGregor** of Chestnut Hill, Mass., died on March 21, 1976 at age 91. After graduating from M.I.T. with a degree in physics, he taught in the Boston Public Schools for 40 years.

Mr. MacGregor was a longstanding member of the Appalachian Mountain Club, having been the first manager of their hut system and at age 88 the oldest person to climb Mount Washington. He was an active bowler and church member, and a member of the Massachusetts Weavers Guild.

He is survived by his wife, Mrs. Ethel (Peck-Hall) MacGregor, a daughter, a son, seven grandchildren and five great-grandchildren. — *S.F.*

## 11

Mrs. Molly Mac Pherson Allen wrote the following letter about the death of her father to the Class of 1911: "It is with deep sorrow that I must report to you '11ers that **Roy Gay Mac Pherson** passed away February 17. You have lost your 'Dingbat' and I've lost my Beloved Bubba. My daughter, Terry, worshiped her grandfather. She lives in Alaska and I persuaded her to stay there with her 3-year-old twins because her husband was up on the North Slope. She sent the following telegram which we consider the most wonderful tribute to and summation of a truly great guy.

"'Mom, here it is. If you want to use it for a eulogy, you may. I guess there is no way to explain my Bubba. He was a knight in shining armor, a hero, but most of all he was gentleness. He was his own independence. He gave to others in patience and love. I am sorry that I cannot be there to support the living with his loss, but, out of the mouths of babes, a piece of wisdom. My 3-year-old son upon seeing my tears at the news of Bubba's death asked why I was crying. I said, 'Because my Bubba had died and gone away.' My son then said, 'Don't worry, Mom. We'll put on our coats and go find him.' My tears cleared and I said, 'We don't have to. He will always be in our hearts.'"

"My son, John A. Crane, Jr., who lives in Scituate, Mass., was a tremendous help to me in cleaning out the house and selling it. Plus his wonderful strong arm on one side, with my dear husband on the other side, at the cemetery. I'm a lucky gal! We brought mother back to Florida with us and she's in a beautiful nursing home in Naples.

"If any of you are ever down on the west coast of Florida, please contact me: Mrs. H. J. Allen, 28 4th St., Bonita Shores, Rt. 4, Bonita Springs, Fla. 33923. Bonita is a little town between Fort Myers and Naples. Keep the faith, God bless, and I'd appreciate hearing from any of you." — *S.F.*

## 12

**Jonathan A. Noyes**, President of the Class, announces that **Lawrence T. Cummings** was unanimously elected Class Secretary at a recent meeting of the Class Executive Committee; Mr. Cummings' summer address (until August 1) is Holderness, N.H., 03245. His first report will appear in the next issue. — *Ed.*

## 13

We were so pleased to receive a phone call from **Bill Brewster**, and Ellen. Bill sounded his usual cheery self. . . . **Walt Muther** writes: "Time takes its toll — in my case, gradually. I had a bad case of flu but got over it at last. I keep my weight down and I have a TroyBilt self-propelled tractor for the garden that does most of the work; the exception: planting."

Jane and **Henry Glidden** just returned from Bermuda and we were glad to hear from them: "Bermuda is a great place to be. This is our first visit here and we're enjoying it all immensely: the sea and its ships, the beautiful old town of Hamilton, a very comfortable hotel, and delicious meals. Flowering shrubs and trees grow luxuriously with very thick foliage and bright blossoms."

It is with a heavy heart that we report the death of **Gilbert Pardey** on January 26, 1976. Gilbert's daughter, Jean Pardey Doyle, writes that he was 85. We were very close for many years and are sending a note of sympathy to Jean on behalf of the class. — **George Philip Capen**, Secretary-Treasurer; **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd., Biddeford, Maine 04005

## 14

**Alden Walitt's** years of hard work as chairman of the San Antonio Art Institute were capped by the dedication of its newly completed building and grounds on May 22, with the Institute's accounts in the black for commitments made up to that date.

The death of **Louis D. Charm** on August 2, 1975, was reported to the Alumni Association in April. The class records show that Louis was with us in Course VI during our first three years. He lived in the Boston area during his active career, and since 1971 had made his home in Reston, Va. In 1917 he married the former Anna B. Garfinkle; she died in 1974, a few days after Louis returned from our 60th Reunion. They had a daughter, Helen Sylvia. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

## 15

Sad losses for our Class continue — **Henry Leeb** died suddenly April 24 in Gladstone, N.J. . . . **Seward Highley** died May 6 in

Medford, Mass. . . . **Bahjat A. Abdulnour** died May 27, 1974, in Beirut, Lebanon. We'll miss these men and the sympathy of our Class goes to their families. . . . **Evers Burtner** wrote: "My wife, Mary Ellen Burtner, died March 27 from a heart attack. A well-attended Memorial Service was held in the First Congregational Church of Kingston, N.H. Mary was a very efficient and talented housewife, making it easier for me to handle a fairly heavy teaching load in the Dept. of Naval Architecture and Marine Engineering. Many Course XIII civilian graduates may recall the Sunday evenings spent at our home during the last term of their senior year. Her wonderful musical ability could respond even to the requests of foreign students from Turkey, China, and South America. This helped compensate for my habit of without warning setting up a written quiz in class, thereby earning the name 'tricky' from my students."

When **Phil Alger** was in Boston in May, as a member of the History Committee of the I.E.E.E. Electro 76 Convention, I had dinner with him. A thoroughly enjoyable evening — and imagine my surprise that Phil, with all his deep serious engineering interest, has a relaxing hobby of doing cross-word puzzles. In June he goes to Zagreb to attend a symposium for the famous electrical engineer, Nikola Tesla. . . . **Alice Anderson** continues to trip around Florida in the winter and to Maine in the summer.

**Arthur Bond**, Casselbering, Fla. writes: "Although I have lost my eyesight, I have developed a certain amount of facility in 'touch' typing that still permits correspondence with friends, and am otherwise in excellent health."

"**Nelson Stone** just sent me a notice of **Jack Dalton's** death. It must have been sudden, for my sister saw him only a short time ago in Winter Park. His career was a great credit to the Class. Although I knew him only casually, these contacts were such that I feel that I have lost a good friend."

"During the past year I received the Elliott Perry Cup of the U.S. Philatelic Classics Society. The national society grants this award annually to an outstanding author of published articles or handbooks dealing with U.S. Postal History, based upon original research. This is a hobby that I have enjoyed immensely since my retirement, but have been forced to relinquish recently, because of failing eyesight." We all sympathize deeply with Arthur and admire his courage.

**Orton Camp** spent the winter at the famous Gulf and Bay Club at Sarasota. Fran and I were there some time ago and we know what a delightful place it is. . . . **Alton "Woof-Woof" Cook** returned from a successful go at the Santa Anita Race Track.

We're glad to see **Ellis Ellicott** enjoying himself. He writes: "I had a pleasant expedition with some friends in February and March, flew to Rio de Janeiro from New York, boarded the 'Appollo,' cruised north along the Brazilian coast stopping at several ports, then landed at Barbados and went by air to New York. I plan a fishing trip to Wyoming in late summer."

**Loring Hall** continues his pleasant life. He writes: "We have just returned from a vacation at Biloxi, on the Gulf Coast. We lost interest in Arizona about three years ago, and have been going to Biloxi in November and March ever since. Phoenix has grown so big that it is just another

smog-filled city and everything is crowded, whereas southern Mississippi is still the 'Old South.' The tempo is restful, the golf courses uncluttered, and the people are delightful. We found summer had arrived at the same time we did this week, so we have been doing a lot of gardening. The bulb plants are exceptionally beautiful this year and the colors are gorgeous. I'm glad we live in the temperate zone, where the miracle of spring is repeated each year. In July we head for Boothbay Harbor, Maine, where we stay at the same place as we have for ten years. Maine is my favorite state, perhaps because all of my ancestral roots are there, but more probably because of the cold, clear water and the pine-scented air. No pollution problems in Boothbay!"

Many of us will agree with **Peter Masucci's** philosophy: "I have no major aches or pains but do have all the minor ones that go with old age. Some one once said that old age is not for sissies. He was right, and especially so when you live by your solitary self."

**Otto Hilbert** continues busy in the preparation of a history of the Corning Glass Works, where he was associated for many years. . . . On May 5, the Greater Boston Chapter of The American Society for Technion Israel Institute of Technology gave a big tribute dinner to **Larry Landers**. Shortly after that Larry was taken suddenly and seriously ill, followed by surgery here in Boston. This dinner and testimonial were a great tribute to Larry. When I saw Larry in the hospital after his operation, he was doing well in his recovery and we wish him all the best.

From Clearwater, Fla., **Bob Mitchell** wrote: "Still ticking off the years, a bit more stiff each year, but get around, and have good health and fun. Foreign travel is off my list now, but I do not miss it, and now am content to putter in the garden in the morning, and swim at the beach in the afternoon. Friends from the north get down to visit — the so-called 'Snow Birds.' All my 'kids' went to Cornell. Too bad none of them went to M.I.T. But I can understand — the hills, the lakes, the sailing on Lake Cayuga, and the winter skiing are very attractive." **Joe Livermore** has not been in good health. We sympathize with him and wish him all the best.

Margaret (Mrs. **Chester M.**) **Runels** could not attend our 61st Reunion. With her sister she was on a long trip to the British Isles. In May she attended her 60th Reunion at Smith — good for her. . . . **Jim Tobey** boasts he is now a great-grandfather and wants to know if he has any competition from classmates!

**Bob Welles** wrote Joyce Brado, our Class Agent, a splendid letter. I do hope we see him here on his eastern trip — he's a delightful fellow. "My daughter is planning a trip East this summer, leaving here about the middle of May, and wants me to come too. She'll have the company of the girl who lives with her (another occupational therapist), also her boxer dog; so they won't need me at all. I'll just be that much more trash in the bus to be kept in order. So I plan to wait until about July 1 to join them. We'll be together to see the parade of square-rigged vessels through New York harbor, drop in on some of our friends and relatives in New England, and then head for Gaspe, a region we have never seen. After a few days there, I'll fly back to my orchard and my job

with the water company."

I hope you and your families all have a happy and healthy summer and see me, if any of you should be here. All the best to you all. — **Azel W. Mack**, Secretary, 100 Memorial Dr., Cambridge, Mass. 02142

## 16

**Maury Holland** wrote of his doctor's orders: "no more travel after my 85th birthday check-up, and the need to send reluctant regrets to: the Industrial Research Institute (now International) where I was to participate in presenting a medal to the founder of I.R.I. in Europe; our 60th Class Reunion; and a State Department three-day conference on 'Detente,' in which my son represents the University of Indiana Law School as an expert witness on Constitutional Law and Legal History. I have been working with the Deputy Secretary of State on 'Detente—the Role of Research and Development Management in World Trade.' But stone walls a prison do not make. I keep working by letter, and phone. I'm co-author of a book, *Research and American Industrial Development* by Harold Vagthorg, President of Southwest Research Institute. (I wrote the forward and the 'Supplement — 50 years in Research and Development Management — A personal view of high-lights.')

In recent weeks, we had telephone contact with **Barney Gordon**, **Dina Coleman**, **Charlie McCarthy**, **Izzy Richmond**, **Dan Comiskey** and **Hank Smith** and all are well. We also talked with **Francis Stern** and he was anticipating a cataract operation late in May and for this reason did not expect to attend our 60th.

We acknowledge with deep regret this letter from Mrs. **Mark Lemmon**: "Mark passed away December 22, 1975, after a long illness, which had kept him from being active, although he was very interested in M.I.T. and the Class of '16 in particular. Mark was a very quiet, modest man, of many and great accomplishments. He always gave M.I.T. the credit; as he said, it was what he learned there that carried him far professionally. May the 60th Reunion of the Class of 1916 be a most pleasant one."

The following is excerpted from a friend's biographical sketch:

After receiving his M.I.T. degree in architecture, Mark Lemmon briefly worked in the office of Warren Whitmore in New York City on such buildings as the Commodore Hotel and the Broadmoor in Colorado Springs. He then enlisted and served as an officer in the 77th Engineering Division in France as the commanding officer of a transport operation.

When he returned from France, he settled in Dallas to begin a long and distinguished career in architecture. The main body of his work was in the designing of churches and schools. Scattered over Texas are 16 churches of his design. In the most dramatic of these, the Moody Memorial Methodist Church in Galveston, glass from the studio of Gabriel Loire of Chartres was first introduced into this part of the world.

For 23 years he was the consulting architect for the Dallas Independent School District, directing a building program of \$250 million. For eight years he was consultant to the University of Texas System and all of its branches during one of its great

periods of expansion. As consulting architect for Southern Methodist University, he designed 20 buildings on that beautiful campus, including the distinguished Perkins Theological Quadrangle.

During World War II, Mark Lemmon was requested by the United States Government to draw plans for an \$18 million bombardier school to be located in San Angelo, Tex. — the plans were to be delivered in 21 days. By working a team of 70 around the clock he delivered them on time.

Mark was married to the former Maybelle Reynolds for more than 50 years and has two sons, Mark L. Lemmon of Dallas, and George Reynolds Lemmon of Topeka, Kansas. Services for him were conducted last Christmas Eve in the sanctuary of the Highland Park Presbyterian Church, of which he was a founder and which he had designed. With its slender, delicate spire silhouetted against the Texas sky, it stands a monument to a good man and a great architect.

We look forward to your cards and letters. Keep writing. — **Ralph A. Fletcher**, Acting Secretary, West Chelmsford, Mass. 01863

## 17

**Jack Wood** writes, "We have had a big rowing regatta out here over Easter with Harvard and M.I.T. sending out crews. The teams used our sailboats at the Yacht Club to bunk on for a week of practice. I was involved in this and with a picnic sail from the Club for our local alumni and the crews. Ross Smith, Director of Athletics, was here and it was good to learn that work on the new boats and the pavilion is going well. We hope to have it ready for fall. I keep busy with the children's program at the Yacht Club, spending most of every day working on some phase of it."

The American Chemical Society's Centennial publication, *Chemical Engineering News*, has an article on "Chemical Technology; The Past 100 Years." Its portraits of three leading founders of the Chemical Engineering profession include **Barnett F. Dodge**. "The first Chemical Engineering text devoted wholly to thermodynamics, B. F. Dodge's *Chemical Engineering Thermodynamics* appeared in 1944. Among his many achievements, Professor Dodge, a member of the first class to enter M.I.T.'s School of Chemical Engineering Practice, and at Yale during most of his professional life, had contributed significantly to the analysis of liquid air plants and high-pressure reactors. It seems not unrealistic to say that the more recent textbooks and courses in thermodynamics as well as the uses of thermodynamics in industry derive from such early influence," the article says.

**John Holton** had a good winter at Casey Key, Fla., and got back to central New York in time to get his garden ready. . . . **Bob Erb** has installed quite a fountain arrangement on his Canaan, Conn., lawn. . . . **Edna and Brick Dunham** entertained **Jim Flaherty** and **Jess Rogers** for a luncheon recently. I learned this when the Dunhams had us for a luncheon. All parties are flourishing as was the Dunham's spring garden.

If you have not marked your calendar for our 59th Reunion, do it now. The days are October 6, 7 and 8, at the popular Northfield Inn. — **Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard**

**O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

## 18

Inevitably — it must happen to all secretaries — there is a dearth of news for these class notes. Therefore I must be inventive. In this instance I record for you two personal experiences involving our Alma Mater during the past month.

On May 8 Selma and I were among the audience at Kresge Auditorium to hear the M.I.T. Symphony Orchestra. To my untrained ears — and my wife's professional ones — this was a superb performance — very close in quality to the world-renowned great musical organizations. The concert hall was completely filled, with about 90 per cent of the attendees being students. The audience was totally absorbed in the performance, which spoke well for the interest of this particular undergraduate group in the humanities as well as professional studies.

Five days later we attended a meeting sponsored by the Boston Stein Club at the M.I.T. Historical Collections. Under the direction of Warren Seamans, memorabilia dating back to the beginning of the Institute have been collected and arranged in an attractive setting. This assemblage has special meaning for our Class — perhaps more than any other; we had two years on Boylston Street and two years at the Cambridge campus. In particular we enjoyed a talk by Warren Seamans on the Class of 1876 with many pictures of the class, the faculty, and the buildings of that day — and the contribution of these particular alumni to M.I.T. and to building a better world. Will the Historical Collections be able to give a similar presentation in the year 2018 about us? When you are next in Cambridge I recommend to you this nostalgic experience. You will get a great deal of pleasure out of it — and perhaps you can contribute a bit of memorabilia from your own possessions.

Through the courtesy of **Sumner Wiley** I have received considerable information about **Wendell Monroe**, who died on March 25, 1976. He received an S.M. in electrical engineering and followed his profession in this field as consulting engineer. He was involved in this capacity with builders of the San Francisco-Oakland Bay Bridge, and with the Chicago Subway System, the Los Angeles Metropolitan Transit Authority, and the Reading and Pennsylvania Railroads, among others. Some of you recall his correspondence in these columns with **Fred Philbrick** about life after death — he now knows the answers.

A note from Beatrice Boyd notes the passing of **Stuart Boyd** on March 30, 1976. Thanks to her, here is a summary of some of the things he did since graduation. On the Class' behalf I have sent a note of condolence to her.

"Stuart worked 37 years for the U.S. Rubber Co. as a research chemical engineer in Naugatuck, Conn., retiring in 1956. While in Naugatuck he was Republican Town Chairman, active in Masonry and boy scouting. After retiring to Florida he became a Shriner and was active in that. We spent three months in Cuba at the request of the company to straighten out their troubles, and we had many wonderful trips to Hawaii, the British Isles, the Caribbean islands, Alaska, and Peru; and our last long

trip two years ago was completely around South America on the Kungsholm. He leaves one son, a grandson now serving in Germany for the third time, and a great-granddaughter."

— **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

## 20

In the April *Physics Today*, a noted Harvard professor tells of receiving a letter from our classmate **Francis Sears** on the last day of his life. It was forwarded by Francis' wife, Mildred, who explained that her husband was keeping up correspondence of an academic nature with a number of people. In the letter were his thoughts about some of the more difficult concepts of relativity theory and how they could be taught. Says the recipient, "The letter bore the same mark of clarity that characterized his textbooks and educational papers. I am honored to have exchanged knowledge with a wise man." A wise man, indeed, was our distinguished classmate.

Further information about the career and family of our eminent classmate, **Skeetz Brown**, in the El Paso newspaper at the time of his passing. Skeetz had been associated with American Smelting and Refining Co. (now A.S.A.R.C.O.) for 40 years. He was in charge of all this great company's mining operations, including exploration. He served as a member of the Alumni Council from 1952 to 1966. He was a member of the American Institute of Mining and Metallurgical Society and was one of the founders of the Rotary Club of Parral, Chihuahua, Mexico. Besides his wife, Margaret, he leaves two married daughters and a son and no less than 15 grandchildren, all of whom live in El Paso.

With keen regret, I must tell you of the passing of another highly valued member of our class, **Joe Margolis**. Joe, who had retired to Sea Air Towers at 3725 So. Ocean Dr., Hollywood, Fla., leaves his wife, Ruth, and two daughters. He was former owner of the Lenox Restaurant Equipment Co. of Boston where he had resided for many years. Joe and Ruth came up from Florida to attend our 50th and they added substantially to that great occasion for they were among the most popular and well-liked couples of the class. Ruth has the heartfelt sympathy of all of us.

As we reach the copy deadline, sad word comes of the death on May 21 of our popular and beloved classmate, **Frank Bradley** of 11 Pine Ridge Rd., Reading, Mass. Frank had long served as assistant to the president of Stone and Webster Engineering Co. An excellent athlete, he was a member of Everett High School national championship football team. He was a fellow of the American Society of Mechanical Engineers and of the National Society of Professional Engineers. He belonged to the Sierra Club of Boston. He held the Boy Scout Silver Beaver Award. Frank leaves his wife, Esther, two sons, two daughters, and many grandchildren. It will be recalled by those attending our 55th that the Bradleys were awarded a prize for the couple having the most grandchildren, an occasion that gave us all a happy opportunity to salute this wonderful couple. Your class will

miss you, Frank. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01870

## 21

At the annual May dinner meeting of the M.I.T. Club of Northern New Jersey, Dorothy (Mrs. **Joseph**) **Wenick** was presented with a framed testimonial honoring Joe's memory: "In recognition of his loyal and devoted service to M.I.T. and this Club for many years during which he gave unstintingly of his time, talents, and friendship, the Club's Outstanding Alumnus Award shall be hereafter named for Joseph Wenick." Other classmates at the dinner included Maxine and **Cac Clarke** and Betty and **Sumner Hayward**; your Secretary made the presentation. Professor Walter Rosenblith, M.I.T. Provost, gave an interesting and amusing talk on the duties and responsibilities of the Provost.

Helen and **Bob Miller** (he is Class Historian) made their annual trek to Cape Cod in the middle of May. Helen was hospitalized for about a week in late April for high blood pressure, but Bob reports a fast recovery and doctor's orders to "take it easy" for a while.

An article in the April issue of *MIT 76*, a supplement to *Technology Review*, tells of the **Samuel E. Lunden** Leadership Grant established by our Assistant Secretary in 1967 to give scholarship assistance to southern California high school seniors at M.I.T. Sam seeks out students showing potential for becoming leaders in national affairs. Seven students have received awards to date amounting to over \$14,000.

Assistant Secretary **Josh Crosby** continues to send in news concerning activities of our '21 Florida contingent. **Whit Spaulding** and he played golf several times with **Royal Wood**, a winter visitor from Connecticut. The Woods, Spauldings, **Herbert Kaufmanns** and **Josiah Crosbys** attended the M.I.T. Club's Ladies Night on March 10. The Crosbys and Kaufmanns play bridge frequently, men against women, but your Secretary has no knowledge as to who is winning. Josh reports talking to **Larc Randolph**, who was in the hospital in February. Now at home, "Larc sounded more like himself but is confined to the second floor and said he was getting bored. He is having a chair lift installed and looks forward to getting downstairs." Josh and Claudia recently returned from a trip to Alabama where they visited the Bellingrath Gardens in Mobile.

The M.I.T. Club's annual picnic on Casey Key on April 25 — "one of the best ever" — and Class of 1921 had the biggest contingent, including the Herb Kaufmanns, the **Tom Duttons**, the Whit Spauldings, the **Jim Parsons**, the Josh Crosbys, the **Phil Paysons**, the **Elliott Peabodys**, and the **Phil Coffins**.

The **Robert Worsencrofts** finally pulled up stakes in Wisconsin and have moved to 10015 Denham Dr., Sun City, Ariz., 85351. They bought their new house a year ago, were delayed somewhat in moving when Bob suffered a slight heart attack, but left Wisconsin in November. Bob writes, "We are still settling in — a considerable change both climatically and socially from Madison — and we have yet to experience a full summer in Airzona. The house is very com-



*Beauty and the Beast — a pen and ink illustration drawn by Bill Elmer, '22, for VooDoo*

fortable, fully air-conditioned, and we have our own citrus trees. We both seem to be in good health."

A brief note from Emma (Mrs. **Leon A.**) **Lloyd** says, "Al has been very busy as Church Historian during the past months. Although he didn't do the actual writing of the history to be published in early June, he did much research and has the business part to manage. Al often drives me for 'Meals on Wheels' when my regular partner is unable to help."

It is my sad duty to report the deaths of five classmates: **George F. Pieper, Jr.** of Milton, Mass., on September 5, 1972; **George F. Lull** of Chicago, Ill., on February 7, 1976; **Isaac Dougherty** of Hamburg, N.Y., on February 21, 1976; **Robert W. Haskel** of Medfield, Mass., on March 7, 1976; and **Edward P. Molloy** of Chicago, Ill., on March 7, 1976. The Haskels and Molloys both attended our 50th Reunion. George Pieper was Superintendent of General Equipment Installation for the New England Telephone and Telegraph Co. Isaac Dougherty was President of Associated Chemists, North Collins, N.Y. George Lull was General Manager of the American Medical Association and later Medical Director of Cook County, Ill. Bob Haskel was Director of Engineering, Standard Chemicals, Natick, Mass. Mrs. Molloy wrote that she and Eddie had planned to come to our 55th Reunion. The sympathy of the class is extended to the families of these classmates.

A news item clipped by **Irving Jakobson** from the *Long Island Press* (May 8) tells of the latest job taken on by our veteran railroader **John W. Barriger**: "'Retirement should be barred by the Constitution as cruel and unusual punishment,' says John Barriger, who was fired for old age after serving three railroads as president. At age 76, he has been railroaded back out of retirement by the Rock Island Lines. This week Barriger became Rock's senior traveling freight agent. Officials of the financially troubled railroad said they need his expertise."

"The Pittsburgh and Lake Erie fired me in 1964 because I was about to turn 65. I became President of the Missouri-Kansas-Texas, but they fired me in 1970 because I was 70. I was president of the Boston &

Maine but they fired me in 1973. And I was retired from the Federal Railway Administration this year because I'm 76. I'm thinking of suing the government for age discrimination. They could charge me money to let me work. For me, railroading comes under the heading of organized sport."

Details of our 55th Reunion will be reported in the October/November *Technology Review*. Have a good summer! — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary for Florida, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary for California, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

## 22

With our South American Mission successfully completed and Technology Day coming up, this hiatus is used to again remind everyone of our 55th Reunion at the Spaulding Inn Club at Whitefield, N.H. . . . We also acknowledge a good letter from **William B. Elmer** of Andover and Thornton New Hampshire Tree Farm. Bill and Cathleen have been staying near Andover while their younger son, Edward, attends Phillips Andover Academy. He is a National Merit Scholarship finalist. Bill's VooDoo drawing of Beauty and the Beast appeared in an article with Bill's youthful photograph in the *Engineering Society of New England Journal*. The write up on Bill as the personality of the month (May '76) is a complimentary discussion of his book *The Optical Design Of Reflectors* and Bill's creative output as a classical musician and published composer of classic works, including a hymn.

Chancellor Paul E. Gray has submitted a memorandum of understanding for the future utilization of endowed funds of the Class of 1922: "Earnings on the growth fund should be used to insure that the Class of 1922 Chair and the Class of 1922 Career Development Chair are endowed at a level which does justice to their distinguished character. After this condition is met, earnings should be used to create new chairs which serve the same purpose as the existing two. One pleasant and encouraging as-

pect of this principle is that, given the nature of the exponential, the Institute will eventually have more chairs which will bear witness to the sustained interest in the support of effective teaching which the Class of 1922 has manifested." These are also recommendations from **Parke Appel** and **Don Carpenter**. **Bill Mueser** has reviewed the standards used and suggests that "Class of 1922 Chair" be used as a standard for all future awards. The new holder of the Class of 1922 Career Development Chair is **Woodie C. Flowers**, Assistant Professor of Mechanical Engineering. He is the first holder of this Chair from the School of Engineering. Professor Flowers, who has been at the Institute since 1966, received the M.I.T. Goodwin Medal for outstanding undergraduate teaching in 1971 with a "rare combination of capabilities: artistic and visual ability, depth in engineering, and innovative talent."

We congratulate **Joseph H. Keenan**, Emeritus Professor of Mechanical Engineering at M.I.T. for his election to the National Academy of Engineering, a result of his contributions to engineering thermodynamics and engineering education. Election to the Academy is the highest professional distinction that can be conferred on an engineer.

The sympathy of the Class has been extended to Mrs. Frank Lorenzo of Newington, Conn., for the loss of her father, **Warren T. Ferguson**. Warren had always been an officer, a fund raiser and one of the most active participants in all our activities. His business connections were in Cambridge, where he could closely follow M.I.T. activities and provide help and backing to all alumni affairs. Warren will be sincerely remembered for his jovial and friendly relationship with many of us.

We also extend our sympathies to the family of **Robert D. Hoffman** of 5th Avenue, New York City and **Erwin J. Smith, Jr.**, of Albany, N.Y.

We have not had many address changes to report recently as Classmates seem to be settling permanently. Good golfing to you all this summer. — **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fla. 33060

## 23

**Julius Stratton** enjoyed his 75th birthday, May 18. He received a large number of personal good wishes. We, belatedly, join in wishing him well and many more years of enjoyable retirement. We salute you, Jay, for your many achievements. . . . **Cecil H. Green** has asked the Alumni Association to begin listing him as Honorary Director, Texas Instruments, Inc. We also recognize him as Life Member, Emeritus of the M.I.T. Corporation.

We recently enjoyed the company of **Katie** and **Herb Hayden**, **Helen** and **Lem Tremaine** and **Doris** and **Pete Pennypacker** at lunch here in Heritage Village. We briefly discussed possible plans for our 55th Reunion. It is again the feeling that we should not try to have the whole thing in the Boston area but instead have a few days on the Cape with attendance at Alumni Day optional. If anyone has any ideas please write to me.

We record the death of **C. Arnold Dutton**

of Niagara Falls, N.Y., on March 13, 1976. "Dut" was born in Oneida, N.Y., in 1899. He entered M.I.T. in his sophomore year, having spent a year at Syracuse University. He graduated with us with a B.S. degree in general engineering. The early years of his career was in the industrial furnace field. In later years he was Vice President and Manager of Construction Sales, and Director of the Buffalo Electric Co. He held high offices in the National Society of Professional Engineers, both national and in Erie County; and was prominent in local affairs, having been called the "Father of the Niagara County Community College." He is survived by his widow, Dorothy Cooke Dutton.

We are sorry to learn belatedly of the death of Commander **John B. Kneip** of Seal Beach, Calif., on March 17, 1975. John spent his career in the U.S. Navy after receiving his M.S. in aeronautical engineering with our class. He was a graduate of the U.S. Naval Academy and was promoted to Commander in 1937.

**William E. Otis** passed away in Ligonier, Penn., on September 13, 1976. He received his Ph.D. degree from Yale University and studied courses in business and engineering administration at the Institute. While with us he was a member of Delta Psi and in later life was associated with The Otis Co. and William Edwards Co. of Cleveland, Ohio.

Lastly we hear of the passing of **Lawrence J. Tracy** of East Orleans, Mass., on March 18, 1976. Lawrence was born in Cambridge, Mass., in 1901, and graduated with us in architectural engineering. In his early career as a structural engineer he was associated with Cleverdon, Varney and Pike of Boston. Later he was structural engineer with Stone and Webster, and Ganteaume and McMullen, also of Boston. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn. 06488

## 24

A 1975 M.I.T. Alumni Register Questionnaire second request brings a note from **Phillipe Lohest**, Docteur en Droit, who writes, "I regret to tell you that my father-in-law, **Eugene Dhooghe**, died on January 26, 1975." His business address is given as Societe Intercommunale Belge Delectricite, Brussels, Belgium. He was awarded his S.M. in electrical engineering, but we have no information on his career.

**Hoyt C. Hottel**, Professor Emeritus in the Department of Chemical Engineering at M.I.T., is a member of the steering committee that will supervise a two-year project, funded by the Energy Research and Development Administration, to revise the National Research Council's massive reference volume on coal chemistry and technology, *Chemistry of Coal Utilization*.

. . . **Clint Conway**, Clearwater, Fla., regretfully advises cancellation of the proposed Fifth Florida Fiesta Caribbean cruise in November. Only four reservations were received, none from Boston area. The proximity of Thanksgiving may have worked adversely, many having plans for family reunions for that weekend. Clint is enthusiastic about approval from his medical advisers to drive his car again.

A note from **Dick Lassiter**, Class Agent, reads, "Had a nice lunch in New York City

with **Frank Shaw**, **Bill Correale** and **Perry Maynard** in April. I do not plan to be at "Technology Day '76," as Bee and I will be at Bay Village, Ohio, and/or Erie, Penn., about that time. Will try to attend the Alumni Officers' Conference in September." — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, Co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

## 25

I find myself reduced to telling about the events on Cape Cod since there are no other news items this month. **Bernie Nelson**, **Prescott Smith**, (both class of 1935), and I have been reviewing the returns from a letter which we sent to the 260 M.I.T. alumni on the Cape. About 70 per cent are retired and the question is — Should we form an M.I.T. Club? The response has been most encouraging. Next September the first meeting will be held.

The Class of 1925 is well represented with eight members on the Cape: **Cliff Abrahamson** lives in East Falmouth; **John Handy** is in Cataumet; **Ralph Norton** is located in Buzzards Bay; in South Yarmouth we find **Ken Proctor**; and in Orleans is **Cap Ranger**. There are three classmates in Chatham: **Pete Goble**, **Will Mahoney** and yours truly. Pete and Will are members of our very active Retired Mens Club and I see them occasionally, but this time of year, they are busy preparing their boats for summer. I have a vegetable garden to prepare. Also, I continue to raise many gladioli as I have for the past 30 years. Each year I try to cut down on the number of bulbs planted but still find myself planting nearly 1,000 and enjoying the unique colors of perhaps 90 different varieties.

So that in the future you won't have to read about my activities please get busy and drop me a line. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

## 26

We again find ourselves faced with a Class Notes deadline prior to reunion — this time a week away. While the attendance is going to be large, there are still many who because of one conflict or another will not make it. Even at the last minute there are changes. **Al Entwistle** has written of the sudden loss of his wife which has made it necessary to cancel out, and **Dick Plummer's** brother, who has always received Dick's mail in Boston while Dick roamed the world, has written that Dick died in London on May 16. Our sympathy to Al and to Dick's brother for these untimely deaths. And for some reason we do not know **Ben Richardson** has had to cancel out. We hope it is not serious.

One classmate wrote that he was a little disturbed that more consideration had not been given, in the Notes and our reunion correspondence, to the classmate who for physical or financial reasons would be unable to participate in our 50th. His message was of sufficient concern that we telephoned him to learn more. We found that he had been somewhat frustrated when he wrote the note because of his inability to do something for the class and that he was

really not "mad" at us at all. We assured him that such a feeling on his part in itself represented a kind of loyalty that our class respects. All is relative — when I see what Mr. Sloan and Mrs. McCormick did for M.I.T. I also feel frustrated — and the present generation of loyal alumni supporters do so much in comparison to most of our efforts, it is really comforting to find someone who wants to help but cannot. I felt concerned when I read his note and our telephone conversation was so satisfying that we want to express the same kind of understanding to any other alumnus who may feel left out for one reason or another. You are *not* left out. You are still a member of a closed and closely knit group — the class of '26!

In preparation for reunion we have been going over old slides. Fortunately your secretary became a photo fan about the time Kodachrome was invented, and by the time our 15th reunion arrived a telephoto lens was part of the equipment. Consequently there are slides of every reunion — some pretty good, some fair, some just for the record. We have seen these slides projected at many reunions but a slide flashes on and off the screen with greater interest to some than to others. In the past year or two a new process has come along that makes it possible to produce color prints direct from Kodachrome slides and the quality is superb. For the reunion, therefore, we have had prints made from 175 slides of all reunions back to and including the 15th. We are struggling to mount them on individual album sheets for perusal by all at the reunion. Most are in the 3R size but a few, such as 1941 slides of **Dave Shepard** and **Bill Lowell**, and 1951 slides of "Liz" and **Jim Killian** and "Lobby" are in 8 x 10s. Those who attend the reunion will see the pictures and an attempt will be made for others who wish to see them to take a look later. It's been a fun project so far but cataloging lies ahead.

Yes, there is even a picture of the class walking into our driveway on the occasion of the visit in 1966 to Pigeon Cove. We have made no mention of Pigeon Cove but all this is still originating from there where the Notes have been written for the past 27 years. During these 27 years there has not been an issue of the *Review* without '26 Class Notes and although we have not checked with Jim Killian, Jim is practically certain that no issue of Class Notes was missed during his 23 years as secretary.

If the back issues are available at M.I.T. I plan to check, hopefully before reunion. So with all these little duties ahead, until we can actually tell you about our 50th, let's say Cherrio. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

## 27

It is not too early to start marking your calendar for June, 1977, and the 50th Reunion. The Reunion Committee has arranged for 1927 to take over the Wianno Club on Cape Cod from Monday, June 6, to Thursday, June 9. Some of the class have already stated their intention to be there, with their wives, as early as Monday; some will come a day or two later. On Thursday, June 9, we all meet at Cambridge, and rooms will be provided in the dorms for our class. Thursday night will be the usual Pops



*Franklin T. Kurt, '27, was honored at a "mini-reunion" of the Department of Aeronautics and Astronautics on June 4 as its first bachelors' graduate (see page 85).*

concert, and at the luncheon on Friday, the Class Gift will be announced.

Contributions are coming in for the 50th Reunion Gift, but not at a rate that assures meeting the goal of \$500,000 announced by **Bud Fisher**, Gift Chairman. As most of you know, any contribution to the Alumni Fund between now and June, 1977, counts toward the 50th Reunion Gift. You'll be hearing more about the Gift from your local committee member. When you hear from him, remember we each have to dig as deep as we can.

**Ray Hibbert** sends me a few brief notes. He and **Bud Fisher**, **Dick Hawkins** and **Dike Arnold**, were in Cambridge in early May for a briefing session on planning a 50th Reunion. . . . **John Morgan** ("Pinkie") **Pinkerton** is in the process of retiring from the contracting company he established when he retired to Daytona Beach, Fla., in 1964, after 30 years in Venezuela with an Exxon subsidiary. Pinkie's wife died in 1971, and he has since remarried (Evelyn Rand) and is continuing to live in Daytona Beach. They hope to get to Cambridge for the 50th.

**Larry Cheney** retired from Uniroyal seven years ago and is living in Old Greenwich, Conn. . . . **Bill Crane** is retired from Anaconda; he lost his wife two years ago. Bill spends part of each winter in Florida and the rest of the year in Middlebury, Conn. . . . **Larry Day** still is called back by the government occasionally to work part-time on a special defense audit. He is one who is planning to be at Wianno.

I have, unhappily, two more deaths to report. **Bob Wise** died suddenly in April. Bob had retired as president of the National Ice Cream Co. of Boston and lived in Brookline, Mass. He was a past president of the New England Assoc. of Ice Cream Manufacturers, and a director of the International Association of Dairy Industries. He had been active in charitable organizations, including the creation of scholarships at M.I.T. and of endowments at Beth Israel and Jewish Memorial hospitals.

**Francois Rousseau** died last October, in Outremont, Quebec, where he lived. He had been chief engineer of the Power Development Div. of Quebec Hydro-Electric, and five years ago had received the Julian P.

Smith Medal, a major award of the Engineering Institute of Canada, for achievement in the development of Canada.

As this is written, in mid-May, your Secretary is still active at New Rochelle City Hall, and finding that it is going to be necessary to make a quick break, instead of tapering off. The deadline is the end of August, a few weeks after these notes reach you. — **Joseph H. Melhado**, Secretary, 24 Rodney Road, Scarsdale, N.Y. 10583

## 28

We hope **Arch Archibald** doesn't mind if we quote some of his recent letter to **Jim Donovan**: "As I grow older, I have the illusion of being busier — which mostly means that I fuss more over less. Fortunately, my current activities are not urgent enough to be affected very much. The notion of being busy is certainly much better than the thought of having nothing to do." This observation applies to many of us now but hitherto has not been so boldly stated. Arch is himself productive and busy developing new steelmaking ideas.

Jim also reports a personal letter from **Howdy Root**. . . . **Clinton Perkins** wrote, mostly to update his address. His winters are spent in Bradenton, Fla., and his summers in Little Switzerland, N.C. . . . **Bill Hurst** says that **Max Bearon** and his wife stopped in Houston especially to see him. . . . **Dave Oiken** hosted the Donovans and the Smiths at his yarn dyeing plant (Dye-craftsmen, Inc.) in Taunton, Mass., late this April. While we were in Florida last March, Florence phoned Frances (Mrs. **Carl F.**) **Myers**. Frances still has her citrus groves, which are managed by a grove caretaking service. Her interest in M.I.T. and loyalty to '28 are strong as always. . . . In May the first **Dr. Benjamin F. Miller** Scholarship awards were made at Ben-Gurion University in Beersheva, Israel. The recipients were two highly deserving medical school students, a girl and a boy. Ben's wife, Judith, was present and addressed the opening ceremony. The memorial, established by Judith and Ben's friends, is a permanent fund that will provide the annual scholarships.

With deep regret we must report the deaths of two classmates. **Walter H. Ridley** died in Concord, N.H., on April 11, 1976, after a long struggle with cancer. His wife, Betty, was thoughtful in sending us the information. She said that in February they had been able to enjoy a trip to Florida where Walter even tried some golf. A note has been sent expressing sympathy to Betty and her family. . . . **Hamilton Rumrill** died on April 4, 1976. Hamilton graduated in Course VI and was an electrical engineer at the General Electric plant at Lynn, Mass., for many years. He was prominent in his Masonic Lodge and in local civic activities. To his wife Barbara we send our heartfelt sympathy. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 01890

## 30

We heard from two of our classmates who, like your secretary, still work full time. **Reg Bisson** is still operating his general building contracting firm under the name W. M. Bisson & Son in Laconia, N.H. Although he plans to retire from the contracting business

later this year, he will continue to do consulting work as an engineer and estimator. Reg is a trustee of the Laconia Savings Bank and the Taylor Home for the Aged, as well as an active member of the local Chamber of Commerce and the Rotary Club. He corresponds occasionally with **John (Marsh) Cleary** and **Nelson Cooper**. The Bissons have four children, including a son who is M.I.T. '60 and four grandchildren. . . . **Joe Becher** still works for Burns and Roe, Inc. as chief consulting engineer in power plant design and construction in Paramus, N.J. He reports as his hobby restoring old stone houses in western New Jersey. . . . **Wilfred (Bill) Eaton** retired some time ago from Raymond International Inc. where he was project control engineer. He did part-time consulting work during 1974, mostly in London, and finally retired in 1975. He has moved from Houston to Corpus Christi, Tex., which he describes as "a beautiful and tranquil city after all the hustle and bustle of Houston." **Henry (Hank) Bates**, who retired as senior vice president in the executive department of Johns-Manville Corporation in 1972, has been spending considerable time traveling. Last year, he and Helen spent more than a month in the South Seas and Far East and made two trips to Hawaii before returning to Los Altos. Earlier this year they took a cruise from San Francisco to Fort Lauderdale through the Panama Canal. Also they spent some time with Evelyn and **Dick Phillips** in Hawaii, including a week at Maui and another week at the Mauna Kea Beach Hotel on the island of Hawaii. The Bates now have 12 grandchildren with whom they are especially popular as the owners of a swimming pool. Hank remembers the pleasant time at Chatham Bars Inn last June and is already looking forward to the 50th Reunion. . . . As previously reported, **Mel Blackwood** retired in 1969 and is living in Franklin, N.H. Mel says he has had two heart attacks and is now taking it easy. This gives him "lots of time to think in this beautiful country of N.H., something that I never had time to do while I was earning a living." The Blackwoods have two children: a married daughter in San Francisco and a married son who earned a Bronze Medal in Viet Nam and now lives in Sanbornton, N.H., near Mel and Lee. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

## 31

The deadline for this issue is May 21 so, unfortunately, I won't be able to report on our class reunion until next time. As of now 58 members have said they will attend the reunion and 46 say they will be accompanied by wives; all in all, it looks as if a good time will be had by all.

When **Randy Binner**, **George Humphrey**, and yours truly, together with our wives, had dinner together a few weeks ago, I believe it was the first time we had seen George since graduation in 1931. He still looks the same and seems to be enjoying life. Talked with **Charley Wood** some time ago; pleased to learn that he is planning to attend the Reunion. A card from **Fred Elser** in Honolulu, another of the class' radio hams, reports that he talked with **John Dyer** recently but that conditions weren't too good. Haven't heard from other classmates since last notes.



Janet and Larry Barnard, '31, (center and right) are honored for their outstanding record as blood donors by Paul Kloss, Blood Donor Recruitment Chairman of the Wellesley Red Cross.

As things look now, Sally and I will be living in Florida by the time these notes are published. We are both looking forward to the move — but will miss our old friends in Westport. — **Edwin S. Worden**, Secretary, 35 Minute Man Hill, Westport, Conn. 06880; **Ben Steverman**, Assistant Secretary, 260 Morrison Dr., Pittsburgh, Penn. 15216; **John W. Swanton**, Assistant Secretary, 27 George St., Newton, Mass. 02158

## 32

**Elmer H. Stotz**, Professor and Chairman of Biochemistry at the University of Rochester's School of Medicine and Dentistry, was the recipient of the University's Alumni Citation for outstanding achievement. Elmer came to Rochester as chairman of the biochemistry department in 1947, and is known for his teaching ability and service to students, his administrative skills, and his contributions to research. At the University Medical Center, he is chairman of the first-year cell biology teaching program and serves on numerous committees. Elmer is the principal or joint author of more than 130 scientific articles. He is co-editor of *Comprehensive Biochemistry*; assistant editor of *Biochemistry*, the journal of the American Chemical Society; a member of the Scientific Advisory Committee of the United Health Foundations, and of the Scientific Advisory Committee of the Nutrition Foundation.

**George W. Falk** has been busy the past two years heading the Citizens Association in Palm Beach, Fla. In addition to his cabinet-making hobby, he is assisting his son in the establishment of a new business. At last report, George intended to spend the summer in Massachusetts. . . . **Ernst H. Anderson** since his retirement in 1971 has recycled to serve God with the Galilean Baptist Mission in Grand Rapids, Mich., as a lay missionary building up a small church in Hopkins, and recently as a Mission Board member and controller of fiscal activity. — **John W. Flatley**, Secretary, Apt. #204, 5100 Dorset Ave., Chevy Chase, Md. 20015

## 33

Top billing this time goes to our distinguished President, **Dayton H. Clewell**.

Through **Ellis Littmann**, we find that Dayt is now participating in the performing arts. Dayt was interviewed on TV's *60 Minutes*. To quote Ellis, ". . . we should be honored that Dayt was so prominent a part of this important television feature." Dayt, our hats are off to you. . . . Sickness in **Art Hungerford**'s family made him miss the Fiesta, he writes. With Art's stepmother having a bad winter, and their daughter's trauma continuing, he could enjoy no out-of-town activities. Art observes that retired life is far more complicated than working life.

Marge and **Bud Lobdell**, of Sarasota, apologize for not writing about their impressions of the recent Fiesta, because after Mexico, they drove all over Texas and New Mexico. He doesn't mention seeing any classmates, though Texas is full of 'em. We even have a Veep there; a guy named **Marshall**. Bud says that the Fiesta was great as usual, and this one was his third, with the Eager Beaver award coming up on the next one.

"Lowell Patrick McClure and Charmian Tashjian (daughter) were wed on July 4, 1975. He is an S.B. 1970 at M.I.T., and Charmian is a B.A. in Music from Northwestern, 1971, Master of Arts at Stanford, 1974, with a minor in Humanities at both Universities." You must have guessed that this was written by **Berj Tashjian**. . . . **William (Bill) Sheppard** comes through with a short capsule of his activities. Bill is now Vice Chairman of Manasota Chapter of Score Corp. of Retail Executives, Sarasota, Fla., Chairman next year. He is also Treasurer of the Manatee Players in Bradenton, and a member of the Board of the West Coast M.I.T. Alumni Club. . . . **John Rumsey** writes his new address, on the other side of the lake. Which lake? Who knows? (John is a great guy, and I know he will tell me more if urged a bit.)

For the first time, we may announce that the Institute has a new kind of Professor, "Adjunct Professor." Who makes it first? Our own **John Wiley**. "This new status is an appointment as Adjunct Professor made to distinguished practitioners who have developed a high level of expertise in fields of particular importance to the M.I.T. faculty and who demonstrate as well a deep commitment to teaching and research within M.I.T." Congratulations, John, from your classmates.

The National Academy of Engineering

announces the election of 104 new members; of the 14 M.I.T. men, three are from our class: **Horace S. Beattie**, I.B.M. Corp., Lexington, Ky., for contributions to the design of business machines, and leadership in word processing; **Dayton H. Clewell**, Mobiloil Corp., New York, N.Y., for leadership in developing new technology for petroleum operations engineering for energy conservation and environmental mechanics; **Richard S. Morse**, M.I.T. Development Foundation, for pioneering in high vacuum technology leading to the introduction of a wide variety of products and processes. Election to the Academy is the highest professional distinction that can be conferred on an engineer. Horace, Dayton, and Dick, your classmates are proud of you, and I offer our sincere congratulations.

Just under the wire comes a note from Betty and **Henry Kiley**. He retired rather early on account of a chronic respiratory situation. They travel yearly to Massachusetts, and to California, where son, Henry, Jr., and his wife, Jane, and their two granddaughters live. Son Kevin is doing graduate work at Virginia Institute of Marine Science. Henry and Betty will visit him and his wife, Kristine, come June. Henry wonders where all these strange classmates come from, who write me for class news. No one can know them all, Henry.

I have compiled a list of classmates with Florida addresses (30 of them), for some future use. However, there are surely many who spend a lot of time in Florida who still use the northern address; to name a few, **Gus Martin** and **Charlie Quick**. In hopes of integrating our forces, I make this small request; will these Florida winter residents, still using northern addresses, please write me their Florida addresses, and include a short biographical sketch for class news and, possibly to use in organizing an annual outing? You retirees all have plenty time, for sure.

Write ye Scribe, or there just won't be any news of the M.I.T. Class of 1933. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

## 34

I'm sorry to say that this month's notes are almost entirely sad news of the loss of classmates. It all seemed to have descended at one time. Last July, **C. Leslie Grahn** of Whiting, N.J., died, but the information only came through fund drive reports. According to the latest Alumni register, he had been retired for some time.

In April we lost **Frederick C. Gans**. He had been with Skidmore, Owings and Merrill since 1940 and was an associate partner at the time of his death. He had been the responsible coordinator for a number of major buildings, including the Lyndon Baines Johnson Presidential Library, a Philip Morris cigarette manufacturing plant in Richmond, the Hirshhorn Museum and sculpture garden in Washington, and the Compton Library at M.I.T. His wife, the former **Priscilla A. Bacon**, is also a member of our class; she studied architecture at the same time as Fred.

Another April passing was **Charles D. Luke**, who received his doctorate in 1934 after graduating in chemical engineering from Iowa State University. In the 1930s he was a consultant to several oil companies

and later professor and head of the Chemical Engineering Dept. at Syracuse University. Beginning in 1934, he worked at Oak Ridge, Tenn., on projects connected with the 1946 atomic bomb test on Bikini and from 1954 until his retirement he held a number of positions with the A.E.C.

Going back a few months, in January, **George T. Fisk** died suddenly in Pompano Beach, Fla. His home was in Shelter Harbor, R.I., and he had formerly been President of A. T. Cross Export Co. Previously he had been a general traffic manager for Booth American Shipping Co.

In March, **Robert J. Frazier** died in Beverly, Mass., after a long illness. He had worked as a civil engineer for the Corps of Engineers from graduation until his retirement in 1967. As one who retired not much later than that, I'm glad he had a chance to enjoy some of the relaxation toward which most of us work.

To conclude this sad litany I have word of a loss that affects a classmate who many of us in the Boston area know. In March, Carla Stevens, daughter of **Mal Stevens**, died in Saarbrücken, Germany, where she was teaching in a German high school under an exchange program. She was only 23 and her death was the result of a faulty apartment heater. Mal, for some years, has been connected with the administration of Brown University and is currently a special adviser to the president of the University.

The words of condolence that I can offer on behalf of the others in the class seem cold and formal but they are nonetheless heartfelt. From a personal standpoint this is especially true with Mal's daughter who had already made a fine start on a promising career.

On to more pleasant things — **Egor P. Popov** of the University of California at Berkeley was one of 104 American engineers elected to the National Academy of Engineering. This honor comes for his work in the mechanics of solids and the inelastic cyclic behavior of structural systems. . . . **Peter Kalustian** writes: "My consulting business in the field of food fats and fatty acids keeps me very busy. About half my activities are with overseas clients. I will be visiting in Australia and Malaysia in June. I am still skiing, but a shoulder injury cut into my skiing season. However, I hope to do some skiing in Australia as the season will be starting there."

To finish on a happy note — several months back I had to report the death of **Johnnie Westfall's** wife, Frances, after a long illness. Johnnie's friends will be glad to know he has remarried — to a lifelong friend. This is good news as Johnnie's health needs watching after his heart attack. — **Robert M. Franklin**, Secretary, Satucket Rd., Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4961 Allan Rd., Washington, D.C. 20016

## 35

I must warn you that all my news this time comes from golfing '35ers who I have contacted to play in the class tournament. **Ham Dow** writes from San Jose, "My current handicap tells the story. I haven't broken 90 in ten weeks. Edie and I just returned from Salt Lake City where we enjoyed the hospitality of daughter Joy, son-in-law, and grandsons for a week. Eugene is a physics

professor at the University of Utah." . . . **Bernie Nelson** writes from South Harwich, "My golf score is more like a bowling score. I will try a few rounds in the next couple of weeks to see if I can break 140. Rhoda and I enjoyed Bermuda and since then have been cleaning up the house for our daughter's wedding and getting the boat in the water. Betsy's wedding was May 1 at the Wychmere Harbor Club. Our older daughter Debbie and two grandchildren are still visiting us." . . . **Hank King** sent a note from Chatham, "Since I saw you at Bernie Nelson's we have moved into our retirement home. The house and grounds need quite a bit of fixing up so it looks as if I will be pretty busy for a while. I haven't played very much golf for a couple of years and have not had a club affiliation since 1973, hence no handicap. In view of this there is no way that I can enter competition based on established handicaps." . . . Bernie, Hank and I will be playing with **Fran Muldowney** at his home course, New Seabury, May 27.

**Dexter Clough** regretfully passes on this year's tournament and adds, "One golf event Fran and I religiously plan on is an annual golf weekend at St. Andrews-by-the-Sea, this year June 24 to 27. St. Andrews is most attractive and still has pure Revolutionary Scotch-English atmosphere." . . . **Ken Finlayson** also had to pass on the golf because of an injured knee that may require surgery. . . . As of this date I have played three rounds all with **Ned Collins'** foursome at the Easton Country Club. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

## 36

Class President **Tony Hittl** and I want you to know that the absence of class notes in the two most recent issues of the *Review* was due to a misunderstanding, not to lack of news. The deadline notices were sent to me rather than to Tony. Since I had not anticipated this I had not left adequate instructions with my daughter, Martha, who took care of my mail during my absence. These notes will make up for it.

In April, I had a very pleasant visit in Hong Kong with **Chik-Suen Lam** and members of his family. Lam, Woo and Company is a major construction firm in the colony, having been the first local firm to construct a large dam. One of his two sons is associated with the company, the other is in the Hong Kong stock exchange. His daughter is married to a biochemist and lives in Dallas. Chik commented that his friends at M.I.T. were largely in Course II since he entered in our sophomore year after two years of college in China. He was sorry not to be able to attend our reunion and sent his greetings. . . . In Tokyo I had lunch with **Tom Kato** and we spent a couple of hours talking about people and places. He wished particularly to be remembered to his Course XV classmates. Tom is associated with Aichi Sangyo Co., Ltd., a Tokyo firm which imports, among other things, welding equipment. His two daughters are married, one living in the U.S. and one in Japan; both studied in San Diego. Chik-Suen Lam and Tom Kato would be delighted to know when any members of the class are coming their way.

Contributions to our class gift to the Alumni Fund have frequently been accompanied by news. This deserves a double

thank you! **Ollie Angevine** reports that his son Eric received an M.S. from the University of Texas and has joined the firm of O. L. Angevine and Associates, consultants in acoustics, in East Aurora, N.Y. . . . **Aaron Loomis** reports that he has retired from formal corporate life and is now operating a small company engaged in the design and manufacture of all wood, high quality toys. He has time for "travel, visiting four married children and eight grandchildren, boating, and just loafing — a good life!" . . . **George Moustakis** has completed 35 years at General Electric Aircraft Gas Turbine Division in Lynn, Mass., and plans to retire this year. He claims a son, two daughters (both married) and two grandchildren.

**Al Bagnulo** has been with Bechtel, Inc., in Gaithersburg, Md., since September, 1974, as Manager, Environmental Projects Office. He remarks that two of his four sons are married and that he has five grandchildren. . . . **Rufus Isaacs**, who is Professor of Applied Mathematics at Johns Hopkins, received the Lanchester Prize of the Operations Research Society for his book, *Differential Games*. . . . **Bob Gillette** has no thoughts of retirement and continues as Chairman of the Board of National Life of Vermont, and is active on the boards of several other companies as well as in civic affairs. . . . **Larry Kanters** reports complete recovery from an operation for lung cancer a year ago and a heart attack the year before that. He's busy, that's for sure. Under his direction Gambles has opened a specialty apparel shop offering "sportswear for the fashion conscious young man and woman." This shop is in Northfield, Minn., and the opening of several more is in the offing.

Sally Garth has written to tell us that an M.I.T. Memorial Scholarship Fund has been established in the name of **William Willis Garth, Jr.** Compugraphic Corp., the company Bill helped found in 1961, has made a most generous contribution and I am sure many classmates will want to earmark their contributions for the fund. . . . **Kenneth Winsor** of Course IV, after not having been heard from for many years, wrote to inquire about reunion plans because he hoped to be in this country in the late spring. His address is Via Martiri Della Sassaua, Forte Dei Marmi, Lucca, Toscana, Italia.

I am sorry to have to report the recent deaths of two members of the class: **Arnold Clarke** of Pleasantville, N.Y., died on March 12, and **Edwin Worthen** of Lexington, Mass., the next day. Arnold was ten years older than most of the class, having worked at several jobs before joining the Byrd Antarctic expedition to the South Pole from 1928-30. He was awarded the Congressional Medal of Honor for his part in the expedition. In 1946 he participated in atom bomb tests in the Pacific as a representative of the Woods Hole Oceanographic Institute. He had been retired for some time.

**Edwin (E. B.) Worthen, Jr.** died from a heart attack following surgery. He had lived in Lexington, Mass., all of his life. He was a practicing architect for many years, associated with the construction of several public buildings in Lexington. He contributed much to the enrichment of the history of his town because of his great knowledge and never ending research. Forced by arthritis of the spine to end his professional career in 1963, he continued to the utmost his special interest in town affairs and local history. His death was indeed a loss to the

community. To Mrs. Worthen and to Mrs. Clarke the class extends its sympathy. — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

## 37

**George Levy** operates two stores known as Chandler Levy Hardware, one in Newton Center and one in Weston (Mass.). He has been president of the Newton Center Business Association for the past three years and recently after resigning, was immediately drafted to become president of the Newton Improvement Association. George and his wife, Barbara, celebrated their 30th wedding anniversary in May and went to San Francisco to visit their older daughter, Janie, who is studying film. Their younger daughter, Nancy, accompanied them on this trip. She is a teaching fellow at Boston College. Barbara is celebrating 20 years with the Woman's Aid for Heart Research which she founded in honor of her father Harry Sims. . . . **Ed Fischer** reports a change of address to 19 Holly Dr., Olathe, Kan. 66061.

It is with sadness I report the death of **Robert H. West** on March 10, 1976. Our sympathy goes to his wife and family. — **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148

## 39

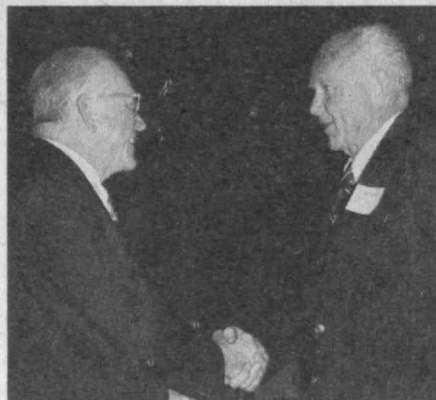
**Morgan Sze** was elected to the National Academy of Engineering for his contributions to the technology of petroleum refining and petrochemical process design and manufacture. . . . **Daniel T. McDonald, Jr.** received a Certificate of Citation from Texas Tech University for his achievements in process and design in natural gas, and for his service to Canada and the United States in petroleum administration and in corporate leadership.

**Simon Roberts** was elected Chairman of the Greater Boston Chapter for the American Jewish Committee for 1976-77. He has been active in inter-faith relations. . . . **Dick Feynman** reminisced on 1943-45 experiences in a talk entitled "Los Alamos from Below," given at the University of California at Santa Barbara. Dick's talk was printed in the January-February edition of *Engineering and Science*.

**Ernie Kaswell**, **Manning Morrill**, **Fred Schaller**, **Paul Stanton**, **Aaron White** and I met with Don Severance '38, Fred Lehmann, '51, and Ron Stone, '59, to discuss activities toward our 40th Class Reunion. All classmates are invited to make their suggestions to those named, and to send along some news for these notes — **Hal Seykota**, Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

## 40

**Doctor of Science: W. H. Krome** George was honored in May at the 83rd commencement of Clarkson College with the honorary Doctor of Science degree. George has been with Aluminum Company of America since 1942. He is chairman of the board as well as Alcoa's chief executive



Greetings from **Gaynor H. Langsdorf**, '32, left, Chairman of the Board of Directors of the M.I.T. Club of Northern California, to **William D. McGuigan**, '42, at the Club's Palo Alto meeting late last winter. (Photo: **Philip L. Molten**, '55)

officer. He serves M.I.T. well, as member of the Corporation and chairman of the Sloan School visiting committee. He lives now in Sewickley, Penn.

**Architect's Honors: I. M. Pei**, elected in May to the American Academy of Arts and Letters, will be awarded the Thomas Jefferson Memorial Medal in Architecture, an international honor for outstanding contribution to architecture. The medal, presented by the University of Virginia, is a duplicate of the one Congress gave Jefferson on the 25th anniversary of the Declaration of Independence.

**Bank Director: John J. Casey**, Executive Vice President of Braniff International Airways, is now a director on the board of Exchange Bank & Trust in Dallas, where he lives. With Braniff since 1968, Casey is also on the airline's board of directors and is responsible for the airline's operations, sales, and service functions.

**Random Roll Call:** The alumni list for the Class of 1940 presently has not one of us living in Arkansas, Nebraska, Nevada, or Wyoming.

Let's hear from: **Saul Namyet**, Sharon, Mass., **Bonner Hoffmann**, Racine, Wisc., **John G. Leschen**, Schenectady, N.Y., **R. Menendez Castillo**, Atizapan, Mexico, **Kingsbury Jackson**, Los Angeles, Calif., **V. D. De Olloqui**, Lewisburg, W.Va., **William S. Woodward**, Carefree, Ariz., **Marshall W. Roberts**, West Hartford, Conn., **John P. McEvoy**, Arlington, Va., **Alfred N. Ackerson**, N. Syracuse, N.Y.

— **Frank A. Yett**, Secretary, P.O. Box 562, Long Beach, Wash. 98631

## 41

By now our 35th Reunion is history and I hope it was all you expected it to be. I'll report the details in the next issue.

I hope you all had a chance to visit the **Ralph Landau** Chemical Engineering Building, named in honor of our classmate. . . . **Carl Mueller** is a new trustee of the Carnegie Corp. of New York. . . . **Charles Peck** has been named Acting Vice President for Business Affairs at the New Jersey Institute of Technology. Charlie was at Carnegie-Mellon University when I first came to Pittsburgh. He is a registered engineer in

# How to Invest in a Slow Economy

Management engineer Anatol W. Bigus, '49, has made a career out of watching industry perform — and trying to help it perform better. Now he's pessimistic: the prospect is for slower economic growth in the future than in the two decades past. And if you have money to invest, he says, be careful and conservative.

Nine reasons for Mr. Bigus' predictions for slowing future economic growth, he writes the Editors of the *Review*:

— The pace of technological advance is lower. "The easiest things have been done, so the problems left are much tougher."

— Our dependence on imported raw materials is growing, and the threat exists of price increases by foreign nations who are in positions to form cartels and organize boycotts.

— The cost of energy is increasing. "There is a close correlation between growth in real G.N.P. and the growth in energy consumed," Mr. Bigus notes, and the rising cost of energy can hardly fail to take its toll.

— The ratio of corporate debt to capital — and to profits — is rising. The fixed charges on this increased debt are a threat to profits, and Mr. Bigus thinks that future industrial growth through further increases in debt may be limited.

— Household debt is up, too — a special threat in an economy with high unemployment.

— The climate for enterprise is increasingly hostile. Now business can no longer base its decisions "purely on the basis of profits and return on investments."

— The prospects for future food shortages

and higher food prices bode ill. "High food prices could shift consumer money from purchases of other goods, thereby slowing the growth of consumer-goods industries."

— The growth — recently at the rate of nine per cent a year — of federal transfer payments looks threatening. "More people are beneficiaries of federal government payments than there are taxpayers who carry the load," writes Mr. Bigus. If the trend continues and "there are not enough people left who will do the work, we will end up with a political system that is characterized more by force than by the consensus we now have."

— The rising power of the "third world" means that the U.S. is no longer looked up to as a world power. So we are losing "our chance of influencing world events in our favor, economically and otherwise, as we were able to do in the past."

Translating this gloomy recital into a recommended policy for personal investments, Mr. Bigus votes nay on long-term holding of common stocks, which are most sensitive to economic conditions and corporate profits. He likes high-grade corporate bonds paying eight per cent or more a year; indeed, he writes, that's very close to the 40-year (1926 to 1965) average gain of common stocks (9.3 per a year). If you must go in for common stocks, choose "large companies, sound balance sheet, one company of an industry, about 20 stocks, investment value computed on past earnings at a conservative capitalization, buy at least one-third off investment value and sell at investment value."

## Watch Everything — Including the Weather

What would induce Mr. Bigus to take a more optimistic view of the future? Watch for any or all of the following, he writes:

— Congress and the administration working together to coordinate monetary and fiscal policy.

— Reduction of the federal deficit by policies that would "insure the availability of investment funds for productive uses rather than for unproductive transfer-type payments."

— Policies that would foster capital investment: encouraging foreign investment in U.S. industry, improved depreciation allowances, differentiated tax deductions for dividends (higher) and interest (lower) income, and reduced capital gains taxes to encourage common-stock investments.

— Deregulation of industry — transportation, for example.

— Signs that business is "doing a better job of explaining its role in the economy to the public."

— Weighing environment controls with more account of their economic impact.

— Continued absence of price-wage controls.

Development of energy policies that reduce dependence on imported oil.

— Reduction in the inflation rate and in long-term interest rates.

"And probably watch the weather," he concludes. — J.M.

four states (N.J., N.Y., Penn., and Ill.) and a Fellow of the American Society of Civil Engineers. He is a member of the New York Academy of Sciences, the American Concrete Institute, the American Society for Testing and Materials, and the Prestressed Concrete Institute, and of three nationally recognized engineering honor societies.

**K. G. McKay**, Executive Vice President of Bell Telephone Laboratories, has been elected to the National Academy of Sciences. . . . **Mason Miller's** activity is "devoted to performance analysis of General Electric CF8-50 aircraft engines now flying on DC10, 747, and A300-B aircraft and associated with the new YC-14 STOL aircraft under development." — **Henry Avery**, Secretary, U.S.S. Chemicals, 2863 Grant St., Pittsburgh, Penn. 15230

## 44

Class notes usually are composed of accounts of special kinds of success: academic, professional, and financial. Among our classmates are probably many whose lives are exemplary of a different mode of success. One, whose very wish to remain anonymous confirms his way of life, can serve as an example. He is a success in the only sense that may really matter. As a

son, as a father, as a soldier, as an engineer, as a husband, as a citizen, and as a friend, he has succeeded. Quietly and unobtrusively he has improved his surroundings. He is one of those people on whom one can depend, in the old sense of "hang on." Without fuss or fanfare he has been there when needed even if the need had not yet been expressed. The usual "success stories" found in our classnotes depend upon the steady, reliable, conscientious accomplishments of capable, unpretentious people like this classmate of ours, but we sometimes tend to forget the importance of these unsung traits.

Late in April the National Academy of Sciences announced the election of 75 new members in recognition of distinguished and continuing achievements in original research. Among those was **Joaquin Mazdak Luttinger**, Professor of Physics, Columbia University. After leaving M.I.T. he spent some time at the University of Michigan in Ann Arbor before going on to Columbia; in the 1948 Alumni Register he was listed as "Exchange Student, Eidgenossische Technische Hochschule . . . Zurich, Switzerland."

**Richard J. McGarry**, formerly Vice President of Stone and Webster Engineering Co., has joined Badger America, Inc., a Raytheon company, as Business Develop-



Richard J. McGarry, '44

ment Manager. His extensive experience in all aspects of new business development in the domestic and international engineering/construction field will be utilized at Badger for the development of new U.S. business.

Have a good summer; and give us a call if you are in the area. We're in the phone book. — **Newton A. Teixeira**, Secretary, 92 Webster Park, West Newton, Mass. 02165

## 47

Gina and I are just about to head south for a combination business meeting and golf jun-

ket, but the mail has been so thin that writing these notes is no problem.

**Leonard Carlson** died suddenly in Barrington, R.I. He was chief engineer of the Watch Division of Bulova Watch in Providence. Our condolences to his wife and three children.

**John Breen**, now at the University of Texas, was elected to the National Academy of Engineering. . . . **Jack Rizika** has sold his interest in his Cambridge business and is now helping a friend in the United Kingdom to get his company on a firm footing. So Jack must spend about half of each month living just north of London. If I recall correctly, Jack has maintained a home near London for quite some years. . . .

**Donald Dean** maintains activity in alumni affairs by membership on the Executive Committee of the Delaware Valley Alumni Association. This group encompasses Wilmington, Del., Camden, N.J., and Philadelphia. He has also taken advantage of some of the M.I.T. Alumni charter trips, having been to Expo 70 in Japan and recently returned from the 1976 trip to Russia.

Trust that you are having some leisure moments over the summer so why not drop a line? — **Dick O'Donnell**, Secretary, 28516 Lincoln, Bay Village, Ohio 44140

## 49

These last two mid-May days have felt more like Rio in summer than Cambridge in spring. One useful outcome: the air conditioning was turned on today to save us all from heat prostration. For whatever reason, our classmates appear to be similarly comatose; perhaps an exaggerated bout of spring fever. In any event, practically no news. And deadline is two weeks before reunion time and our class cocktail party. Pity.

What we have is good news: **Harold G. Ingraham, Jr.**, Senior Vice President and Chief Actuary at New England Mutual Life Insurance, has been appointed to the Board of Governors of the Society of Actuaries. . . . And **Ira Dyer**, once my roommate, has been elected to the National Academy of Engineering as "founder of research and educational programs in ocean engineering and an authority on noise and turbulence." Congratulations. And to the rest of us, best wishes to all. — **Frank T. Hulswit**, Secretary, Acorn Park, Cambridge, Mass. 02140

## 50

**August P. Doering** has recently been promoted to manager of commercial printing plate research at S. D. Warren Co., a division of Scott Paper Co., located in Maine. August has worked in synthetic fibers with Celanese and Uniroyal, in textile coatings and adhesives with National Starch and Chemical Co., and with printing plates at Azoplate. . . . **Vinson R. Simpson, Jr.**, was recently elected president of Marathon Electric Manufacturing Corp., a national manufacturer of motors, generators, and control systems located in Wausau, Wisc. Vin is former president and director of the Trane Co. in LaCrosse, Wisc. . . . **Paul J. Berger** lives in Sharon, Mass., and is an associate with Fay, Spoffard & Thorndike, Inc. of Boston.

**Bey Blanchard** is president and general manager of Plasticolors, Inc., which he



Vinson R. Simpson, Jr., '50



founded in 1970 in Ashtabula, Ohio. Plasticolors, Inc. has 30 employees, and makes nationwide sales of colorant and dispersants to plastics, rubber, and adhesives industries. Bey and his wife have three children: a son recently graduated from Ohio State; a married daughter in Chicago; and a daughter who is now a freshman at Ohio State in the College of Fine Arts. . . . **John H. Blum**, married and the father of three sons, is resident engineer at R. H. Macy & Co., Inc. in Pennsylvania. . . . **Herman N. Bockstruck** is senior engineering associate of the Olin Corp., W-W Division, East Alton, Ill. He is married and has three children.

**William Murphy** has been elected vice president in charge of home office services for the New England Mutual Life Insurance Co., Boston. Bill joined the company in June, 1974, as second vice president after serving as director of buildings and grounds for Harvard University. He and his family live in Wellesley, Mass. . . . **Claude J. Pasquier** has been promoted to vice president in charge of program management at Litton Industries' Amecom division. Amecom, based in College Park, Md., produces electronic warfare systems, telecommunications, radio communications and radio navigation systems for military and civilian government agencies. Claude is listed in McGraw-Hill's *Who's Who in Science and Technology* and is a member of the Institute of Electrical and Electronics Engineers, and a director of the Wild Goose Association, for people in the radio navigation field. He, his wife and three children live in Severna Park, Md.

**Bob Boyden** is president of Metropolitan Machinery Associates and lives in Gillette, N.J. . . . **Henry Boyles**, Director of Chemical Products for the Olympic Manufacturing Co., is married to Margaret Boyles, author/designer of *Needlepoint Stitchery*, *Beginners' Needlepoint*, *Bargello*, *The Art of Bargello*, *The Art of Rug Making*, and *American Indian Beadwork Designs Adopted for Needlepoint*. The Boyles live in Atlanta, Ga. . . . **Barney Byrne** is purchasing agent for Monsanto Co. in St. Louis, Mo. — **J. T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

## 51

Here's my last report as Class Secretary, and it's a short one. By the time you read this, my successor will have a replenished backlog of news items from our 25th Reunion, and this column will again be of a length befitting the grand Class of '51.

**Merton C. Flemings** was elected to the National Academy of Engineers for his innovations on solidification processing. . . . **Herbert H. Woodson**, of the Mechanical Engineering Department at the University of Texas, will present the keynote address at a special session of the 50th Annual Meeting of the Society of Petroleum Engineers of A.I.M.E. As one of five panelists, he will project future trends in the petroleum industry with emphasis on manpower resources and industry requirements for the future.

**John B. Aycrigg** is now Chief of Diagnostic, Medical Mental Health Services, Division of Correctional Services for the State of Colorado. . . . **Bernard Rothzeid** has been promoted to full professor at City College of New York School of Architecture and Urban Studies.

An interesting transition from business executive to sculptor has been achieved by **Jerome Kirk**. He now lives in a new home near the top of one of the rugged Los Tularos ridges where eye-arresting kinetic sculpture (shining moving metal art) can be seen at the rear and cliff side of the house. Sculpting was an avocation until 1967. Since that time his output has been considerable, including "Quest," a monumental outdoor wind-driven mobile 32 feet long and weighing six tons. It is almost double the size of Alexander Calder's, the next largest mobile sculpture on record. This effort rated an entry in the *Guinness Book of World Records* as the largest mobile. Kirk uses aluminum, cortan and stainless steel for his objects.

**William C. Gibson** spent much of 1975 working on ships in the Persian Gulf. . . . **Howard D. Chapman** is now Vice President of Marketing for List Industries, Inc. in Harvey, Ill. This firm manufactures lockers for school, sport, industrial, commercial and residential use, and portable gates for traffic control, safety and security use. . . . **Roger Harvey** is Consulting Engineer and Technical Consultant for New York Testing Laboratories, Inc. — **Fred W. Weitz**, Secretary, 4800 S.W. 74th St., Des Moines, Iowa 50321

## 52

**R. P. Bigliano** has become Engineering Manager of the Scientific and Process Instruments Division of du Pont Corp. . . . **Richard H. Baker III** is serving this year as the President of the 90-piece Rockford, Ill. Symphony Orchestra. . . . **William D. McKinley** has been named Director of Data Acquisition Systems at the Equipment Division at Raytheon Co. He will be responsible for acquiring and managing the division's



William D. McKinley, '52

business in intelligence, early-warning, range-instrumentation, and counterweapon radar systems. He has been with Raytheon since 1954. Mr. McKinley, his wife Suzanne, and family, reside at 87 Westgate Rd., Wellesley Hills, Mass.

The March 15 issue of *Business Week* reported that **Joseph F. Alibrandi**, President of Whittaker Corp., has completed surgery on the large conglomerate. Since taking over ailing Whittaker five years ago, Alibrandi has sliced off and fused 89 of the combine's 140 separate companies to create a more manageable 51-unit conglomerate. In the process, he has slashed the company's debt from \$324 million to \$184 million while increasing net worth. The resulting company earned a \$9.9 million profit in 1974. Whittaker still has a varied line of business. It builds yachts, manages hospitals, fabricates and distributes steel, and produces specialty chemicals. Prior to his position at Whittaker, Alibrandi was senior vice president and head of Raytheon Co.'s Missile Systems Division. — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass. 01741; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif. 94301

## 53

Whoever said "no news is good news" is full of baloney; it makes for bad class notes and irritable class secretaries. So, please shape up.

Newspaper clippings: **Martin Levine** is getting into local politics, having just filed to run for the school board in Manchester, Mass. He is currently Manchester's representative on the North Shore Regional Vocational School Committee, has two teenage daughters, and works for the Smithsonian Astrophysical Observatory in Cambridge. . . . In early April **Bruce Beckley** participated in a debate on the nuclear power controversy and the implications for society of nuclear technology. He is manager of nuclear projects of Public Service Co. of New Hampshire, Inc. and spoke for the controlled use of nuclear energy. Earlier, he was associated with Yankee Atomic Power Corp. and was the project manager for a nuclear plant in Wiscasset, Maine. . . . **Frank Heymann**, now Senior Engineer, Technology Development, Steam Turbine Division of Westinghouse Electric Corp., was recently granted the A.S.T.M. Award of Merit and named a Fellow of the American Society for Testing and Materials. The award is granted for distinguished service to the cause of voluntary standardization, and Heymann received his for "... advancing the voluntary standardization of methods of test and specifications in the field of liquid

and solid particle erosion and cavitation." He is active in a number of professional societies and in 1958 received the A.S.T.M. Charles B. Dudley Medal for his paper, "On the Time Dependence of the Rate of Erosion Due to Impingement or Cavitation." . . .

No more news, so a comment on my recent visit to Paris: Should you go there, be prepared to spend a cool million. Everything except the METRO (the Paris rapid transit system) is very expensive — even coffee, and certainly hotels, clothing, good food, and fine wines. (The opera is out of sight.) In short, go for sightseeing and strolling but not for bargains. Even with medium wines, a good dinner in Paris will run \$25 or up per person. It is a beautiful, interesting, and photogenic city — night and day. For my personal recommendations for good places to eat or buy fine, old cognac, drop me a line. — **Martin Wohl**, Secretary, 7520 Carnegie Ln., Pittsburgh, Penn. 15221

## 54

While many of us will be "soaking up the rays" during summer activities, **Felix Rapp** puts old sol to work in cutting down his year-round New England heating bills. Besides providing a technical challenge and saving some money, his home solar heating experimental installation has spawned a promising new company: "Do-It-Yourself Solar Energy." . . . **Everett Chambers**, now a full Colonel in the Air Force, is Director of Operational Requirements for Research and Development at the Pentagon. Ev received an M.B.A. from Auburn University's Montgomery Alabama extension last year.

**Paul Valerio** reports that he is still doing structural consulting in Great Neck, N.Y., and that he has three boys in high school and one girl in junior high school. . . . **Paul Gray** has been elected to the Board of Directors of the M.I.T. Development Foundation, Inc. This non-profit organization assists scientists, engineers and entrepreneurs in the development of business strategies to expedite commercial applications of science and technology.

It is with regret that we report the passing of **R. Thomas B. Peirce, Jr.** of lung cancer in Philadelphia, Penn.; **George J. Schulz** in New Haven, Conn., and **H. A. John Green** in Whitstable, Kent, England. Our sincere sympathy is extended to their families. — **E. David Howes, Jr.**, Secretary, Box 66, Carlisle, Mass. 01741; **Charles Masison**, Assistant Secretary, 76 Spellman Rd., Westwood, Mass. 02090; **Louis Mahoney**, Assistant Secretary, 6 Danby Rd., Stoneham, Mass. 02180

## 55

It's been a busy year, and we need your notes for the column. **Philip Molten** had an exhibition of his photographic essays of architecture and landscape of northern California at the M.I.T. Faculty Club during March. . . . **Walter Seelbach** has been honored by Motorola, Inc., for a recent patent application involving an improved output circuit for high-speed semiconductor devices. Walter is the laboratory manager of research and development for the Motorola Semiconductor Products Div. at Scottsdale, Ariz. . . . **A. David Rossin** is the 1976 Chairman of the Chicago section of the

American Nuclear Society, and **Allan Schell** is the 1976 Chairman of the Boston section of the I.E.E.E. . . . **David L. Peterson** is the Director of the Duluth Dept. of Water and Gas, and he writes that he has been thoroughly involved in the controversy that raged over asbestos-like sub-microscopic particles in the water supply drawn from Lake Superior.

On the academic scene, **Robert L. Coble** is on leave for the 1975-76 year and is spending the interval with USERDA in Germantown, Md., where he is planning materials research programs in support of the energy technologies. . . . **Charles C. Ladd** is on his first real sabbatical leave in 14 years. He expected some free time, but he is as busy as ever writing a book, lecturing in Iraq, and consulting in Japan, Nebraska, and Florida.

Two architecture graduates are in the news. **Marilyn Fraser**, who has conducted an independent practice in Wellesley, Mass., since 1960, was elected Chairman of the Wellesley Planning Board for 1976. She is also the representative to the Metropolitan Area Planning Council, where she serves on the Executive Committee. Marilyn has taught at M.I.T., Wellesley College, and the Boston Architectural Center. She is a member of the A.I.A. and the Boston Society of Architects. . . . In 1976, **Robert G. Dyck** became the first Director of International Programs at Virginia Polytechnic Institute and State University. He has been at Virginia Tech since 1970, when he was named Director of the Center for Urban and Regional Studies. In 1973 Dr. Dyck held a Fulbright-Hays Faculty Research Fellowship to study health planning in Yugoslavia. Upon his return he chaired the program in Urban and Regional Planning at Virginia Tech.

We have belatedly learned of the death of two of our classmates. **Per G. Lagerberg** of Sandviken, Sweden, died in 1970, and **Robert R. McMath** of Chesnee, S.C., died on December 19, 1975. — **Marc S. Gross**, Co-Secretary, 3 Franklin Court, Ardsley, N.Y. 10502; **Allan C. Schell**, Co-Secretary, 19 Wedgemere Ave., Winchester, Mass. 01890

## 57

A clipping from an Acton, Maine, newspaper informs us that **Charles Kadlec** is seeking election to the Acton school committee. He and his wife, Lesley, have four young children who will keep him active in the Acton schools for a number of years. Chuck feels that this is the best way for him to be instrumental in improving the quality of the system, providing more and better programs and alternatives, and spending less money — which is the difficult part. . . . As a professor at the University of Miami, **Ralph Warburton** is working on an interesting project. The university and the Southwest Banking Corp. are sponsoring a nationwide architectural competition and exhibition. The entrants are to design a 50-acre in-town community of 7,000 residential units for a downtown area of Miami — the prize is \$10,000. Ralph is the professional advisor for the project.

**Vytautas Klemas** has been appointed by the National Research Council to its Committee on Remote Sensing Programs for Earth Resources Surveys (CORSPERS).



Frank J. Heymann,  
'53

Vytautas is an associate professor in the College of Marine Studies of the University of Delaware, where he directs research programs in remote sensing of coastal environment and resources.

It would be great to hear from some of you — all of you — so we could pass some news on. — **Fred Morefield**, Secretary, 285 Riverside Dr., New York, N.Y. 10025

## 58

Here we are at the edge of the Bicentennial summer and hardly any news has arrived for the last four months from ye olde classe. Send word: one by mail or two by phone. If you call when you visit Boston for the Bicentennial bash, classmates, all will be forgiven. You can reach me at our offices down on the Boston waterfront, telephone 227-4337, or at home, 262-0596. Let's get together!

From down under, **Mike Balderston** writes: "My contract with the Australian Post Office ran out so the family and I returned to the U.S. to see relatives and friends. We were back over four months but gradually decided we'd become 'Aussified,' so returned to Australia promptly. The Post Office had been split up in the meantime, but fortunately there was another opening in the Satellite Study Group and I was re-employed in short order in the new Telecommunications Commission. Any classmates passing through Melbourne, please give a call." . . . More welcome mats are out. Janet and **Dick Procunier** would like to compare notes with old friends who may be in the San Francisco area. They are just a short BART trip away and Dick can be reached at the Environmental Protection Agency.

**Mac Jordan** has been promoted to President of Kerr-McGee Refining Corp., a wholly-owned subsidiary of Kerr-McGee Corp., in Oklahoma City. This division is involved in refining and marketing of petroleum products east of the Rocky Mountains.

. . . **Malcolm Johnson** has been named Vice President of Foamseal, Inc., in Michigan, manufacturers of urethane foam systems and dispensing equipment. . . . **Martin Victor** recently transferred to Offutt A.F.B. where he is Chief of Aerospace Medicine in the S.A.C. Surgeon's Office. . . . **John Seavey** has been appointed Vice President of Engineering for RF Systems, Inc. in Cohasset, Mass., where he will be responsible for all engineering activities and expansion of the firm's satellite communications systems. . . . At Hamilton Standard Division of United Technologies, **John Lovkay** has been named Division Vice President of Electronic Systems. Previously, he was Director of the Equipment Development Laboratory at the National Weather Service of the U.S. Department of Commerce.

One of our class renaissance men, **John Boynton**, is still a free-lance engineer and writer. John writes: "My poetry books are selling well and I now have three novels in various stages of completion. The cottage in Aspen I am building is nearly done and is available for rental now. I am now a grandfather!!" . . . On the technical publishing front, **Joseph Robertshaw** is coauthor of *Planning and Design: The Systems Approach*, published in 1975. . . . **Richard Glantz** has just recently joined Digital Equipment where he will be heading up a software reliability program. To celebrate



John Seavey, '58

the new job, Dick advises that "we're moving to a larger house and both houses were handled without a broker — delightfully easy and quick, I found."

Following the 15th Reunion, **Mark Tenney** resigned his Associate Professorship of Civil Engineering at the University of Notre Dame to devote full time to his consulting firm. Currently, TenEch Environmental Consultants has offices in South Bend, Ind., and Louisville, Ky. Mark was awarded the Harrison Prescott Eddy medal from the Water Pollution Control Federation in 1973. Mark was remarried to Jane Morris Shepherd in June, 1974. . . . **Charles Gorodetzky** is engaged in research in pharmacology at the NIDA Addiction Research Center in Lexington, Ky. He and Barbara have four children. He received his M.D. from Boston University Medical School and a Ph.D. at the University of Kentucky in pharmacology in 1975.

Sharp-eyed readers of the April, 1976 issue of *Fortune* magazine will have spotted a picture of **Roy Thorpe** in his alter-ego avocation of railroad repairman. As most of you may know, Roy bought a private railroad car, the Hampton Roads, and refurbished it for business and vacation travel trips throughout the U.S. Railroad people call these cars "private varnish." The rest of us just have to settle for "airport modern."

Have a good summer and hope to see you. And write, right? — **Michael E. Brose**, Secretary, 30 Dartmouth St., Boston, Mass. 02116

## 60

We're back after a one-month hiatus brought about by a dearth of news. We need information to write this column, so drop a line to let us all know what keeps you busy these days.

Remember those fiberglass Tech Dinghies that beckoned you out on the Charles as we were entering freshman? Well, they're 23 years old now and in need of replacement. The new boats, which are considerably drier, lighter, and faster than the previous model, were designed by **Halsey C. Herreshoff**. Halsey, a yacht designer with the family boatyards in Bristol, R.I. (they produced the first wooden Tech Dinghies 40 years ago), was navigator on the *Courageous* when it successfully defended the America's Cup in 1974.

Several members of the class have been appointed full professors at M.I.T. **Richard deNeufville** has become a professor in the Department of Civil Engineering, where he chairs the Technology and Policy Program. He is known for two textbooks on systems analysis, and he has recently held visiting

appointments at the University of California and the London Graduate School of Business. . . . **Alan V. Oppenheim**, '59, is with the Department of Electrical Engineering and Computer Science. He is co-author of a text on digital signal processing, and his current research activities include speech and information processing. . . . **James K. Roberge** is in the same department, and his professional interests include electronic circuit and system design. He has written one book in this area and is co-author of another. . . . **David H. Staelin** also is with Course VI, and his special area of interest is radio astronomy. Dave has been involved in studies of the microwave spectra of planetary atmospheres, and he is co-discoverer of the Crab Nebula pulsar.

**Douglas Sinclair**, Professor of Optics at the University of Rochester, has been appointed chairman of the U.S. National Committee for the International Commission for Optics. Doug received the Adolph Lomb Medal of the Optical Society of America in 1968 for his work on lasers, and he is editor of the *Journal of the Optical Society of America*. . . . **Herbert Fox**, Dean of the Division of Science and Technology at the New York Institute of Technology, has been named Vice President for Education of the American Institute of Aeronautics and Astronautics. Herb is an associate fellow of the A.I.A.A. and has served on several of its committees. His interests include application of aerospace technology to national needs, and he was chairman of the first Urban Technology Conference.

Our daddy-of-the-month award goes to **Larry Elman**, whose son, David, was born on March 29. Larry says that his wife, Joan, is looking more radiant than ever, and it appears that David is "cursed with my looks not hers." Larry also reports his continued research on helicopters, his membership in the active reserve, and his involvement with the Bradley Air Museum in Windsor Locks, Conn.

One more reminder: no news, no notes. — **Robert F. Stengel**, Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

## 62

**Victor Schneider** has spent seven years at Purdue University in the computer sciences department as an Associate Professor and was editor of *Sigplan Notices*, one of the special interest group publications of the Association for Computing Machinery. Last year, he decided to move on to something new and moved to Los Angeles in May, 1976. He is now with Aerospace Corp. working in his specialty of computers and software systems. He would be interested in hearing from other M.I.T. alumni in the area.

. . . **Anthony J. J. Rourke**, married Carolyn Rolston, and they are expecting their first child. He is president of the firm of Anthony J. J. Rourke, Inc., Hospital and Health Care System Consultants, a firm his father formed 20 years ago. . . . **Jerome A. Winston** is a lecturer at Preston Institute of Technology, where he is a Director of the Australian Center for Leisure Research and Planning. He is in charge of mathematics and research methods, lecturing within the Department of Leisure Studies and the School of Social Work. He has had various short texts/workshop guides for use in training administrators published in Australia. —

## 63

May, 1976. This month's column is a post-deadline contribution — it appears through the good graces of your friendly *Tech Review* editors. After four years of delivering my mail to 18022 Gillman Street, the U.S. Postal Service was thrown when the letter with the deadline notice was addressed to 18022 Gillman Ave. By the time the letter got to me the second time the deadline had passed. Well, undaunted, I sat down at my typewriter anyway, and here is the result.

This being a big political year I will start with the big political story in the Class of '63. As you read here some months back **Woody Bowman** was engaged in a tight primary battle for a nomination for the Illinois House of Representatives. Three candidates were vying for two spots on the November ballot. It was a close one, but Woody made it; the first place finisher garnered 34,000 votes, Woody had 33,000, while the loser managed 30,000. Woody wrote that the campaign was pretty grueling: standing on train platforms in the early morning hours (often in near zero weather), campaign activities until early afternoon, teaching one class in the late afternoon, and then endless coffees and forums until late at night. He went door to door many evenings and called on more than 500 people in their homes. He made two discoveries: almost everybody is at least cordial to a candidate, but hardly anybody can think of a question to ask on the spur of the moment. Woody's spring vacation at the University of Illinois coincided with the end of the campaign, and he spent the two weeks in West Virginia with his parents. Nothing like home cooking to help one recuperate. Woody plans to give up teaching and devote full time to legislative service (assuming he makes it through the November election). Our congratulations, and good luck in Springfield.

Moving right along, we will put in a book plug for **Henry Nau**. Henry's second book *Technology Transfer and U.S. Foreign Policy* will be published this fall by Praeger. He writes, "Come on classmates. Let's make this one a best seller." Sounds like absorbing light reading. Henry is currently on leave from George Washington University, spending a year in the Dept. of State on a fellowship from the Council on Foreign Relations. He invites us to come and see him in the Office of the Undersecretary for Economic Affairs. We may just drop by.

**Julian Ayres** reports that he graduated from Emory Medical School in Atlanta in June, 1975. He begins ophthalmology residency in July, 1976, at Emory. . . . **Elizabeth D. Cox** has a new job as a Member of the Technical Staff with Bell Labs in Naperville, Ill. She is currently living in Darien, Ill., with her husband, Art, her 11-year-old son, Robert, and her 16-year-old stepson, Tom. . . . **Dan Gross** has been elected Senior Vice President of Colonial Penn Group. He is also President of Colonial Penn Insurance Co., the property/liability insurance subsidiary of Colonial Penn Group. Dan joined Colonial Penn in 1969 as an actuary. He is a Fellow of the Society of Actuaries and a member of the American Academy of Actuaries.

## 64

Greetings, classmates! Well, we almost drew another blank. Much more of this and I may take it personally; then one of you will have to take over this pleasant monthly interlude. All kidding aside, it really is pleasant, *when there's news*. Thanks to *Tech Talk* and our ever-friendly Alumni Fund envelopes, there is a tidbit or two.

**Bob Rothman** is now Manager of Engineering of Chromizing Co. (Gardena, Calif.), a division of Chromally American Corp. which does repair and coating of turbine components. . . . **James M. Flink**, of the Dept. of Nutrition and Food Science at M.I.T., has recently been promoted to associate professor. All of Professor Flink's degrees were earned at the 'tute: S.B. in Industrial Management, S.M. in Chemical Engineering, and Ph.D. in Food Science and Technology. His research interests include freeze drying of foods, structure of dried foods, development of novel protein resources and artificial fruits from seaweed extracts. In 1971 Professor Flink successfully used freeze-drying techniques to save historically valuable papers that had been water soaked in a Greenland fire. The papers had been frozen to preserve them until a way could be found to dry them out without causing the ink to run!

**Robert A. Weinberg**, of the Dept. of Biology at M.I.T., has also been promoted to Associate Professor. He received his B.S. and Ph.D. in biology from M.I.T. and joined the faculty in 1973. He is a member of the M.I.T. Center for Cancer Research. He previously was a biology instructor at Stillman College in Tuscaloosa, Ala., in 1965-66; a postdoctoral fellow with Dr. Ernest Winocour at the Weizmann Institute, in 1969-70; a postdoctoral fellow with Dr. Renato Dulbecco, The Salk Institute, La Jolla, Calif., in 1970-72, and a postdoctoral fellow with Dr. David Baltimore at M.I.T. in 1972-73. Professor Weinberg is a native of Pittsburgh, Penn., and currently lives in Boston.

C'est tout, mes amis! Write and ye shall read the results in this corner of your *Technology Review*. For all of you who forget to send in your 1975-76 Alumni Fund contributions by June 30, take heart. The Institute gratefully accepts them even when they're late. Do it now. Remember the fun we had. Help make it happen for someone else. Have a good summer. Enjoy! Ciao! **Steve Schlosser**, Secretary, 11129 Deborah Drive, Potomac, Md. 20854

## 65

**George Kossuth** reported that the birth of their third child (second son) ended a fine year. George is working at the Draper Labs. . . . **J. David Raney** is a management analyst for Straub Clinic and Hospital and is also active in preserving Hawaii's natural beauty; he served the past two years as chairman of the Hawaii chapter of the Sierra Club and is presently Vice Chairman of the Hawaii Citizen's Advisory Committee to the Coastal Zone Management Program. . . . **Michael White** is now Associate Professor



Daniel J. Gross, '63

in the School of Public Administration at U.S.C., teaching financial management and planning of health services and conducting research. Rand McNally released the second edition of *Cases in Public Management*, which Michael co-edited with R. T. Golembiewski, in March. Judith is an affirmative action consultant at U.C.L.A., and the Whites are currently househunting on the west side of Los Angeles.

From *The Tech*, I learned that **Richard Sidell**, who has been in the mechanical engineering department as an instructor and assistant professor since getting his Sc.D. in 1972, has been promoted to Associate Professor. The Sidells are living in Wellesley. . . . The *New Haven Register* (no, I do not regularly read it, but the staff of *Technology Review* scans it) had a recent article on **Bruce Morrison**. After getting his Tech degree in chemistry, Bruce got a master's in chemistry from Illinois and then his law degree from Yale. He joined the New Haven Legal Assistance Association upon graduation in 1973 and is regarded as the "superstar" of L.A.A. attorneys according to the *Register*. Bruce made the paper because he was being considered for the position of director of the L.A.A. — **Edward P. Hoffer**, Secretary, 12 Upland Rd., Wellesley, Mass. 02181

## 66

Just returned from the tenth reunion where I had the dubious honor of being elected class secretary by running unopposed. **Eleanor Klepser** and **Joe Patterson** will be working with me as assistant secretaries. The next issue will contain reunion details, but here is some news in the meantime.

I am living in Manhattan having left Ford Motor and Detroit six years ago to work for Citibank. I remain a happy bachelor and am playing lots of golf. . . . **Steve Disman** and **Allen White** also work for Citibank. Steve and Donna have two girls and should be back to New York in July after an assignment in Detroit with one of our subsidiaries. Allen and Jaye live in Princeton, N.J., and have one boy with another expected in mid-July. Allen is in charge of auditing the Bank's worldwide consumer activities.

**David Mundel** left Harvard last year for Washington and the Congressional Budget Office where he is trying to make some sense out of our federal budget. David and Elisabeth have two boys. . . . **Ken Brown** (our new class president) has kept me posted on some of the members of the class who are on the Institute's faculty. Ken is the Associate Dean for Student Affairs. . . . **Keith Stolzenbach** was recently promoted to Associate Professor of Civil Engineering

and was also awarded the A. D. Little Chair for Environmental Science and Engineering. . . . **Stu Madnick** was at the reunion and was recently promoted to Associate Professor of Management at Sloan. . . . Others on the faculty: **Bob Pindyck**, Associate Professor of Management; **Monte Graham**, Assistant Professor of Management; and **Nicholas Negroponte**, Associate Professor of Architecture.

The **Fred Webb's** had a second son only a few days before the reunion. Fred is living in Bedford, Mass. working for A. D. Little. . . . **Judy Perrolle** reports that she is entering Brown University in the doctoral program in sociology. . . . **Henry (Fritz) Schaefer** was at the Institute in May to give a seminar and is a professor in the Chemistry Dept. at Berkeley. . . . Finally, I am happy to report that **Pete Blankenship** and **Woody Stoddard** still are playing with "The Invaders" and have been appearing at Boston high schools and colleges, cashing in on the oldies kick. They appeared Saturday at the reunion. . . . **Tom Jones** remains alive and well in the Boston area where he is working for Epsilon Data Corp. . . . **Stu Nemser** reports that the Nemser's and **Ted Kaplan's** spent their vacation in Bermuda last month. Stu and Lelaire are in Wilmington, Del., where Stu is with DuPont. Ted and Susan are down in Tennessee where Ted is working at Oak Ridge. Stu reports that he had beat Ted at tennis consistently (Ted was not called for confirmation) and also informs me that he had a hole-in-one playing golf last week.

**Bill and Eleanore Klepser** have been in Port Allegheny, Penn., since January, where Bill is Plant Superintendent for Pittsburg Corning. Eleanore reports that they have two girls and are enjoying the quiet hills of Pennsylvania. She also reports that **Howard and Muffet (Shork) Chatterton** are living in Bowie, Md., and have three girls. Muffet is with the A.E.C. and Howard is with the Navy. . . . **Betty Vander Molen McKenna** is in Thousand Oaks, Calif., and at last word was working for I.B.M. The McKenna's have two girls. That makes three former coeds with eight children — all female. Let's see, two to the eighth power is. . . .

As we all know, the Class of '66 has not really been well represented in these columns. Hopefully, we can turn that around, but Eleanore, Joe and I can only do it with your help. So start the process of getting the cards and letters coming. — **Paul Rudovsky**, Secretary, 340 East 64th St., Apt. 10B, New York, N.Y. 10021

# 67

**Paul Tarantino** has transferred to the U.S.S. *Enterprise* for 15 months duty, including an eight-month deployment to the western Pacific. Hopefully Paul and Anne will get together in Hong Kong when the ship visits there. A daughter, Catherine Elizabeth, was born January 28. . . . Having received his Ph.D. in environmental engineering from Cornell, **Joel Brainard** is working at Brookhaven National Laboratory on the energy problems of the Northeast. . . . **Eugene Kleinberg** has been promoted to Associate Professor in the Department of Mathematics at M.I.T. He received a Ph.D. from Rockefeller University in 1969 and delivered a series of lectures at the Interna-

## Economic Non-Science

Has econometrics — the computer-based quantitative science of economic measurements — within it the key to true economic understanding?

As Assistant Vice President of the Federal Reserve Bank of Boston, Stephen K. McNees, Ph.D. '70, reads most of the major economic forecasts, and evaluating them is an avocation as well as part of his day's work. Dr. McNees judges that the forecasters' success varies widely, and that economics has yet to achieve the condition of an exact science.

In the Federal Reserve Bank's *New England Economic Review* this winter, Dr. McNees came down on the side of judgmental — rather than "mechanical" — forecasts. (Of the judgmental forecasts, he finds those compiled by the American Statistical Association/National Bureau of Economic Research

well worth attention — "never worse than the median.")

By "mechanical" Dr. McNees means forecasts generated by computers from econometric models and issued precisely as generated; even when the outcome appears improbable to the forecaster, there is no subjective adjustment. In general, such "mechanical" forecasts are not as accurate as judgmental ones.

But "mechanical" forecasts are better than others at predicting gross national product and levels of fixed investment. Their success is so great, in fact, that Dr. McNees thinks the question of why econometric models are so satisfactory on these indices of the economy, and not others, is worth specific research.

But pending that work, he writes that "the contribution of econometric models to forecasting accuracy can neither be established nor dismissed." — J.M.

tional Logic Colloquium held in Cambridge, England in 1970. . . . **Joe Ferreira** has been promoted to Associate Professor in M.I.T.'s Department of Urban Studies and Planning. . . . I had a good telephone conversation with **Bob Howard** last week. Bob is still in Miami where he continues to work too hard for his own good. I would like to hear from a few more of you. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

# 68

Sorry about missing last month. We went to Israel for a two-and-a-half-week vacation and the deadline came while we were still recovering from jet lag. We had a nice time meeting some M.I.T. people there; Jane and Ira Turner, '65, live in Haifa where he is doing electronics work. Rebecca and Bernie Zeigler, S.M. '64, who are cousins of ours, live in Rehovot where he works at the Weizmann Institute. Much to our surprise, the day we got back home a letter arrived from **Ray Boxman** to say that he is teaching at Tel Aviv University, and trying to build a lab to study vacuum arcs there. His wife, Edie, is an economist for Bank Leumi, Israel's largest bank. They report spending a lot of free time hiking around the country and add, "If anyone likes the taste of fresh strawberries in the winter, as well as fabulous avocados and mandarin oranges, this country is the place to live!"

This month was big on foreign mail. An announcement arrived from Geneva informing us that, "Lynda et **Harvey Newman** ont la grande joie de vous annoncer la naissance de leur fils Daniell Kai, le 23 avril 1976, Poids: 3 kg. 660 g., Hauteur 52 cm." Harvey is in Geneva for a C.E.R.N. postdoc and we assume that he and Lynda are enjoying "going native." . . . **Don Batchelor** "finally" received his Ph.D. from the University of Maryland in plasma physics and is now with the Thermonuclear Division of Oak Ridge. The Batchelors love Oak Ridge and feel at home among all the M.I.T.ers there.

**Howard Shaw** got his Ph.D. from the

University of Michigan after a brief intermission in systems analysis and computers. He's now teaching math at the University of Massachusetts at Amherst. He adds, "Life is good." . . . From beantown we hear that **Paul Ware** is at Polaroid in Waltham as Technical Supervisor in inspection of color receiving sheet, helping to develop the new Polacolor II film. He would appreciate hearing from fraternity classmates who are still in the area. His address is: 34 McNamara St., Stoughton, Mass. 02072.

**Ron Rosen** has recently been promoted to Manager of Time Sharing Resources at Shared Educational computer systems. He and Marilyn spent the winter skating and cross-country skiing. . . . From the Big Apple comes a note that **Henry Brenner** is Assistant Professor of Chemistry at N.Y.U. after a postdoc at Berkeley. He writes, "I am enjoying New York so far, but money disappears at a fantastic rate."

**Jack Russell** is at Columbia Pictures Industries as Manager of Special Projects. After leaving the 'tute he received a masters in polymer materials from Polytechnic Institute of Brooklyn and an M.B.A. in finance from Columbia. He has worked previously at Grumman Aerospace and American Cyanamid. . . . **Michael Yokell** is teaching economics at Washington State University, where he has been since he received his doctorate from the University of Colorado last year. In 1974 he participated in the first U.S.-Soviet mountaineering expedition in the Pamir Mountains of Central Asia. His wife, Jane, has a doctorate in plant ecology. — **Gail and Mike Marcus**, Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

# 69

The news is sparse this time. **Donald Collins** reports that he is still living with his wife and child in Shawnee, Okla. He is working with the Indian Health Service in Shawnee. . . . **Sam Jacobs** writes that as of about April, 1976, he began working for Wyle Laboratories as a Systems Engineer. His

work is in digital circuitry design. ... **Michael Rodriguez** is pursuing degrees in biomedical engineering, neurophysiology, and karate.

Hope all of you have an enjoyable summer. — **Peter Peckarsky**, 950 25th St., N.W., Washington, D.C. 20037

## 70

The summer news is coming in rather slowly. However, several short notes were received. **Jonathan T. Salmon** is employed as a scale engineer by Bell Helicopter in their government marketing department. He also wrote that he was married and has one son — 18 months old. ... Canada is the present residence of **Y. S. Nikhanj**. He is presently engaged in active uranium exploration programs near Albuquerque, N.M., however he expects to be back in Canada within a year thereafter.

M.I.T. telethons made some contacts. **Hugh Masterman** has two children — Lisa, 3, and Thomas Robert, 4 months old. Hugh lives in Littleton, Mass., where he has recently become vice president of Engineering Display Components, Inc. Formerly, he was associated with Raytheon and had returned from a business convention in Beverly Hills. ... **Karen Wattel Arenson** called me concerning fund raising and we exchanged news. — **Robert Vegeler**, Secretary, Kennerk, Dumas, Burke & Backs, 2120 Fort Wayne National Bank Bldg., Fort Wayne, Ind. 46802

## 71

**Elaine I. Savage** recently received a Ph.D. in materials science from Brown University. She is the first woman to receive an engineering doctorate from Brown. She also earned her M.S. there. Elaine works for the U.S. Department of Transportation. ... **Richard J. Hawryluk** writes: "After graduating from M.I.T. in 1974, I went to Princeton University, Plasma Physics Laboratory, as a post-doctoral fellow. Now I am a staff member and still working on plasma physics problems related to fusion research. In February, Mary Katherine McMahon (Wellesley, 1974) and I were married." ... **Jay Mackro** writes "I am currently back in school. I spent the first two years after graduation at the Institute earning an S.M. degree in mechanical engineering. The next three years were spent at Digital Equipment Corp., designing printing terminals. Then those familiar urgings to change careers and location began to influence me: as a result I am a first year M.B.A. student at Stanford University."

For those who knew him, the following only proves that truth is stranger than fiction: **Frank A. St. Claire** is now associated with the law firm of James H. Wallenstein, in Dallas. After working for John Hancock, Frank enrolled in the N.Y.U. School of Law where he was the first president of the student body to be elected from the first year class, and he was on the Moot Court Board. Frank was the co-author of the property section of the annual survey of Texas law in the *Southwestern Law Journal* and spoke at the Survey Symposium at Southern Methodist University on May 10. Incredible!!

**Rebecca Grant Ascoli** married Eric Ascoli (M.I.T. '72 E.E.) and settled in Guatemala two years ago. She received an



**Julie A. Olson**, '76, is headed for doctoral study in molecular biology at the Rockefeller University, New York. Here she is with two officers of the M.I.T. Quarter Century Club, holding the Club's check for \$1,000 — the first Quarter Century Scholarship made possible by the Club's successful travel program. With Ms. Olson are **Joseph F. Lynch** (left), Treasurer of the Club, and **John E. Newcomb, Jr.**, Executive Director.

S.M. and an engineering degree in soils before marrying and then she and her husband cruised from Boston to Florida in their homebuilt "yacht." She has been active in Guatemala: modeling, translating, and free-lancing for foreign engineering firms. She is currently working in the engineering division of A.I.D. doing some reconstruction after the earthquake in Guatemala. She and her husband survived on a waterbed on the 13th floor of a very slender building. She likes the work because a great deal of emphasis is being put on soil mechanics and geology. The night before the quake they had dinner with Bob McKinley's, '70, parents. He is at Harvard now. Rebecca mentioned that she saw **Sally Harvey** occasionally while in Boston. Sally was with the E.P.A. and last year had an internship in Washington. She hasn't heard from Sally recently but remembered that she enjoyed rowing (crew) and dirt bike riding.

Please write if you can. Note my address change as of August 1. — **Hal Moorman**, Secretary, P.O. Box 497, Brenham, Tex. 77833

## 75

I've heard from or about the following classmates: **Joel Voelz** is currently treasurer of a small chemical firm; he's attending the University of Chicago for a master's degree in business and "might go for a Ph.D. in business or a law degree — undecided. Would like to return to the Institute someday." ... From a March clipping of the New Britain (Conn.) *Herald*, I see that **Kenneth Rumstay** played the part of Mr. Brownlow in the Berlin (Conn.) Education Association's production of "Oliver"; he's now working on his master's degree in astronomy at Wesleyan University. ... **George T. Tremblay** has written in *Appalachia* about "Solar Energy for the A.M.C. Hut System." It seems that solar water heaters, similar to the type he worked on for his U.R.O.P. research at Pinkham Notch, will be installed this summer at the Appalachian Mountain Club's Zealand Falls Hut in the White Mountains.

Six classmates were the co-recipients of a prize from the American Society of Planning Officials earlier this year for their paper, "Capacity Building: An Alternative Approach to Citizen Involvement in Planning," based on their work in Rockport, Mass. **Jay W. Wollenberg** is now employed

by William Graham Consultants of Vancouver, B.C., **James B. Gust** works for the Norfolk, Va., Planning Board studying declining neighborhoods and determining which neighborhoods are most suitable for rehabilitation, and **John B. Wilbur**, **Kay M. Anderson**, **Vic Frankiewicz**, and **Elizabeth R. Lund** received their bachelor's and master's degrees from the Department of Architecture this June. — **Jennifer Gordon**, Secretary-Treasurer, 5 Centre St., #32, Cambridge, Mass. 02139

## 76

Some news of marriages has reached me by word of mouth. **Mike Bookman** and **Julia Khorana**, '75, were wed on June 11, 1976, in Boston. Mike will be going to Harvard Medical School, and Julia will be working at the Beth Israel Hospital. ... **Dave Roberts** married Joanna Kolstad, Simmons, '75. (I cannot seem to find any additional details. When I get them, I'll let you all know.)

**Marsha LaVoie** and **Larry Hardy** were married on June 12 in Cambridge. Larry will be in the Ph.D. program at the University of California at Berkeley, and Marsha is hopeful of finding a job. Good luck. ... **Paula Mossaides** and **Michael Miller**, '70, were married on May 29. Both will be working for Tektronix in Oregon. ... **Mike Cutrera** and **Terri Alterici**, wed on May 29 at the M.I.T. chapel, will both be attending the University of Oregon for graduate study.

**Karen Jones** and **Skip Richards**, '72, were married on July 11 in South Hampton, Long Island. He'll be working for Data General in Massachusetts, and she'll be studying biochemistry at Tufts Medical School. ... **Steven Edelson** and **Lori Boboroff**, Simmons, '76, have wedding plans for August 15. He will be working for Watkins Johnson in Gaithersburg, Penn. ... **Tony Rullan** and **Maria Roso Mascaro** of Puerto Rico will be married on August 14. He will be working for Westinghouse, but from what I've heard, he hasn't been assigned a location yet.

I would like to know what each and every one of you is doing. Let me know of your activities or those of any other of our classmates. With your help, we shall have class notes. However, be assured I shall try to write to as many people as I can. — **Arthur J. Carp**, Secretary, 67 Badger Cir., Milton, Mass. 02186

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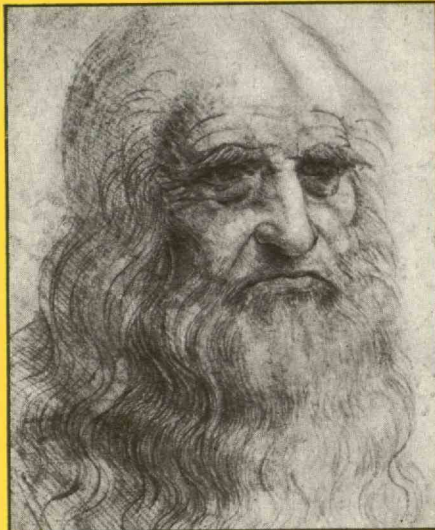
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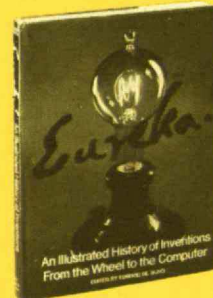
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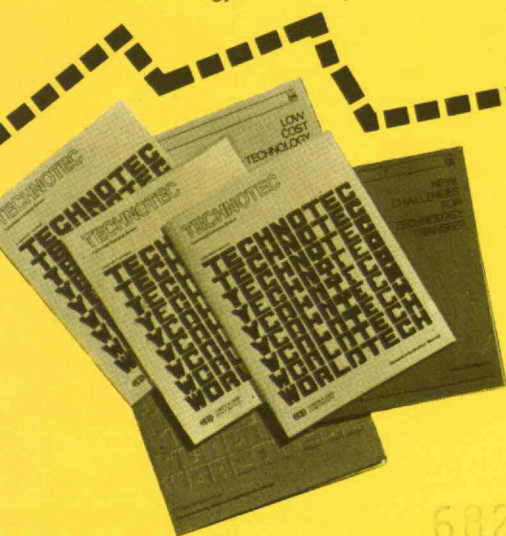
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